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Edition June 2026
Published by : NODIA
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CHAPTER 1

Measurements and Experimentation

SUMMARY

1. NEED OF UNIT FOR MEASUREMENT

Measurement is the process of comparing a given physical quantity with a known standard quantity of the same nature. In everyday life as well as in scientific studies, measurement plays an important role because it helps in expressing quantities in a clear and uniform manner.

A unit is the quantity of a constant magnitude which is used to measure the magnitudes of other quantities of the same nature.

The magnitude of a physical quantity is expressed as Physical quantity = (numerical value) × (unit)A unit can be chosen if it has'appropriate properties.

2. UNITS

In the study of physical quantities, units play a fundamental role in expressing measurements in a clear and standardized form. Without units, numerical values alone would have no meaning and could lead to confusion. To simplify the understanding and measurement of various physical quantities, units are broadly classified into different types.

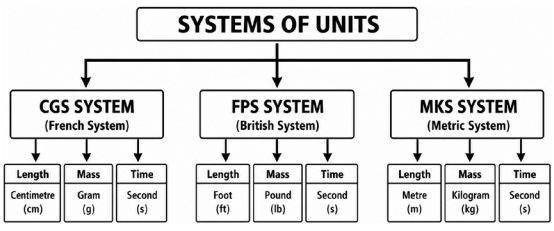
1. Fundamental or basic unit: A fundamental unit is that which is independent of any other unit or which can neither be changed nor be related to any other fundamental unit.
2. Derived units: Derived units are those which depend on the fundamental units or which can be expressed in terms of the fundamental units.

Examples of Derived Units

Quantity	Definition	Derived unit	Symbol
Area	length × breadth	metre × metre	m^2
Work or energy	force × displacement	kilogram × $\frac{\text{metre}}{\text{second}^2}$ × metre = joule	$kg\ m^2s^{-2} = J$
Pressure	$\frac{\text{force}}{\text{area}}$	$\frac{\frac{\text{kilogrm} \times \text{metre}}{\text{second}^2}}{(\text{metre})^2}$ $= \frac{\text{newton}}{(\text{metre})^2}$ = pascal	$kg\ m^{-1}$ $s^{-2} = N$ $m^{-2} = Pa$
Resistance	$\frac{\text{potential}}{\text{current}}$	$\frac{\frac{\text{kilogram(metre)}^2}{\text{ampere} \times \text{second}^3}}{\text{ampere}}$ $= \frac{\text{volt}}{\text{ampere}}$ = ohm	$kg\ m^2A^{-2}$ $s^{-3} = V$ $A^{-1} = \Omega$

2.1 Systems of Units

There are three systems of units used worldwide. They are CGS, FPS and MKS.



1. CGS system or French system : The unit of length is centimeter, the unit of mass is gram and the unit of time is second.

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2. FPS system or British system : The unit of length is foot, the unit of mass is pound and the unit of time is second.
3. MKS system or Metric system : The unit of length is metre, the unit of mass is kilogram and the unit of time is second.

System Internationale d'unites or SI system

According to this system, there are nine fundamental units, including two angular units.

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	Kelvin	K
Luminous intensity	candela	cd
Electric current	ampere	A
Amount of substance	mole	mol
Angle	radia	rd
Solid angle	steradian	st-rd

For expressing large or small numbers/amounts, prefixes are used.

3. UNITS A LENGTH

1. The SI unit of length is metre (m).
2. A metre is defined as the distance which light travels in $\frac{1}{299,792,458}$ of a second in air or vacuum.

Sub-units of Metre

3. Centimetre, millimetre, micrometre or micron and nanometre.

Non-metric Units of Length

Bigger Units

4. Astronomical unit (AU): One astronomical unit is equal to the mean distance between the Earth and the Sun.

$$1A.U = 1.496 \times 10^{11} m \approx 1.5 \times 10^{11} m$$

5. Light year (ly) : A light year is the distance travelled by light in vacuum in one year.

$$1ly = 9.46 \times 10^{12}\text{km}$$

6. Parsec : One parsec is the distance from where the semi-major axis of the orbit of the Earth subtends an angle of 1" (one second) at the centre of the Sun. One parsec is 3.26 light years.

$$1\text{par sec} = 3.08 \times 10^{16}\text{m}$$

Smaller Units

Angstrom $(\mathring{A})$: $1\mathring{A} = 10^{-10}\text{m} = 10^{-8}\text{cm} = 10^{-9}\text{nm}$

Fermi(f): $1f = 10^{-15}\text{m}$

4. UNITS OF MASS

1. The SI unit of mass is kilogram (kg).
2. One kilogram is defined as the mass of a cylindrical piece of platinum-iridium alloy kept in International Bureau of Weights and Measures at Sevres near Paris.
   The sub-units of kilogram are gram (g) and milligram (mg).
   The non-metric unit of mass is atomic mass unit (amu) or the unified atomic mass unit (u).

$1\,\text{a.m.}u = \frac{1}{12}$ th the mass of one carbon-12 atom

5. UNITS OF TIME

1. The SI unit of time is second (s).
2. A second is defined as $\frac{1}{86400}$ th part of a mean solar day.

   $1\,\text{s} = \frac{1}{86400} \times$ one mean solar day
3. In 1964, one second was defined as the time interval of 9,192,631,770 periods of a specified energy change in the cesium-133 atom.

Common Units of Time

4. Minute (min), Hour (h), Day, Month, Lunar month, Year, Leap year, Decade, Century and Millennium.

Guidelines for Writing Units

5. The symbol of a unit, which is not named after a scientist, is written in lower case.
6. The symbol of a unit, which is named after a scientist, is written with the first letter of his name in capital.
7. The full name of a unit, even when it is named after a scientist, is written with a lower initial letter.
8. A compound unit formed by multiplication of two or more units is written after putting a dot, cross or leaving a space in between the two symbols.
9. A negative power is used for compound units, which are formed by dividing one unit by the other.
10. A unit in its short form is never written in plural.

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6. MEASUREMENT OF LENGTH

Least Count of a Measuring Instrument

1. The least count of an instrument is the smallest measurement which can be taken accurately with it.
2. The least count of an instrument is the value of the smallest division on its scale.
   Smaller the least count of an instrument, the more accurate the measurement.

Measurement of Length with a Metre Scale

3. A metre scale is a scale with length one metre which is graduated in cm and has subdivisions in mm.
4. There are 10 subdivisions in each cm.
5. The value of one small division on the metre scale is 1 mm. Thus, its least count is 1 mm.
6. Precautions should be taken while measuring the length of an object.
7. The limitation of a metre scale is that it can measure the length correctly up to one decimal place of a centimetre.

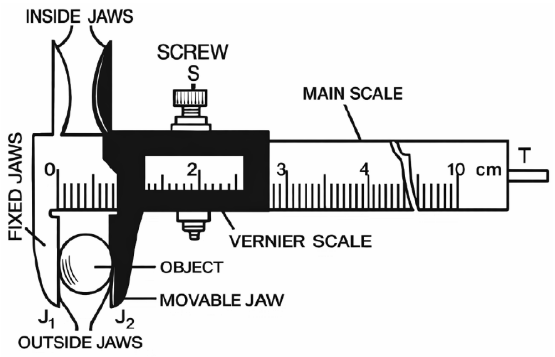
Principle of Vernier

8. Two scales are used in this technique. One is the main scale, and the other is called the vernier scale.
9. The least count of vernier is equal to the difference between the values of one main scale division and one vernier scale division. This is called the vernier constant.
10. 'n' divisions of vernier are equal to n^{-1} divisions of the main scale. Therefore, the value of one division of vernier $= x - \dfrac{(n-1)\,x}{n} = \dfrac{x}{n}$

$$L.C. = \frac{\text{Value of one main scale division } (x)}{\text{Total number of divisions on vernier } (n)}$$

7. VERNIER CALLIPERS

A vernier calliper is also called a slide calliper



The main parts of vernier callipers and their functions are given below :

Part	Function
Inside jaws	To measure the internal diameter of a hollow cylinder or pipe.
Outside jaws	To measure the length of a rod, the diameter of a sphere and the external diameter of a hollow cylinder.
Main scale	To measure the length correct up to 1 mm.
Vernier scale	To measure the length correct up to 0.1 mm.
Strip	To measure the depth of a beaker or a bottle.

The least count of a vernier calliper is given as

$$\text{L.C.} = \frac{\text{Value of one main scale division}(x)}{\text{Total number of divisions on varnier}(n)}$$

7.1 Zero error in vernier callipers

The zero error is equal to the distance between the zero of the main scale and the zero of the vernier scale.

Kinds of zero error

There are two kinds of zero error—positive and negative zero error.

(i) Positive zero error: When the zero mark of the vernier scale is on the right of the zero mark of the main scale, the zero error is said to be positive.

(ii) Negative zero error: When the zero mark of the vernier scale is on the left of the zero mark of the main scale, the zero error is said to be negative.

1. The correction due to zero error, that is, the correct measure of the length is
   Correct reading
   = Observed reading – Zero error
2. Positive zero error gets subtracted and negative zero error gets added to the observed reading.

8. PRINCIPLE OF SCREW

The pitch of the screw is the distance moved by the screw along its axis in one complete rotation of its head. There are graduations along the circumference of the head of the screw. There are 50-100 graduations. This is called the circular scale or head scale.

The pitch of the screw is 1 mm. If there are 100 divisions on the circular scale, then the least count of the screw is $1/100 = 0.01$ mm $= 0.001$ cm.

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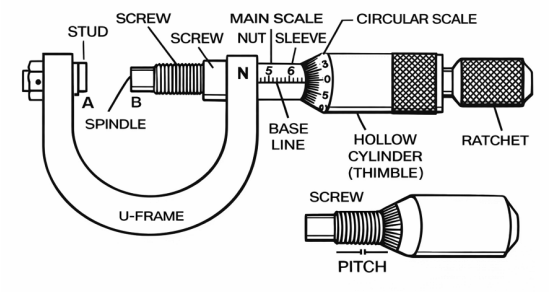
The least count of a screw is the distance moved by it in rotating the circular scale by one division.

$$\text{L.C.} = \frac{\text{Pitch of screw}}{\text{Total number of divisions on circular scale}}$$

9. SCREW GAUGE



The main parts of a screw gauge and their functions are given below.

Part	Function
Circular scale	To read length correct up to 0.01 mm.
Main scale	To read length correct up to 1 mm.
Sleeve	To mark the main scale and the base line.
Thimble	To mark the circular scale.
Ratchet	To advance the screw by turning it till the object is gently held between the stud and the spindle of the screw.

9.1 Pitch and Least Count

The pitch of a screw gauge is the linear distance moved by its screw on the main scale when the circular scale completes one full rotation.

The least count is the linear distance moved by its screw on the main scale when the circular scale is rotated by one division.

$$\text{L.C.} = \frac{\text{Pitch of screw}}{\text{Total number of divisions on circular scale}}$$

Kinds of zero error

1. There are two kinds of zero error—positive and negative zero error.
   (i) Positive zero error: When the zero mark of the circular scale is below the base line of the main scale, the zero error is said to be positive.
   (ii) Negative zero error: When the zero mark of the circular scale is above the base line of the main scale, the zero error is said to be negative.
2. The correction due to zero error, that is, the correct measure of the length is

   Correct reading

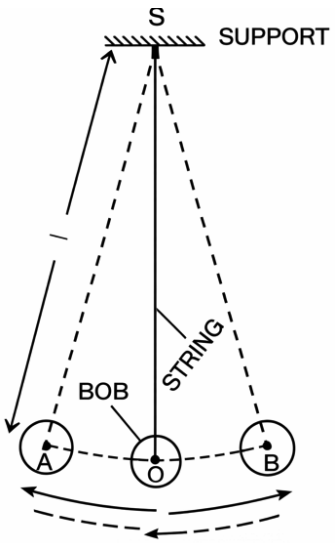
   = Observed reading – Zero error Backlash error

   Due to wear and tear of the threads of the screw, it is observed that on reversing the direction of rotation of the thimble, the tip of the screw does not start moving in the opposite direction at once, but it remains stationary for some part of rotation. The error caused due to this effect is called backlash error.

10. MEASUREMENT OF TIME AND SIMPLE PENDULUM

10.1 Simple Pendulum

A simple pendulum is a heavy point mass called a bob suspended from a rigid support by a massless and inextensible string.



When the bob at the rest position is moved to one side and released, the pendulum is set in motion. The rest position is called the mean position of the pendulum.

Terms related to the simple pendulum

1. Oscillation: One complete to-and-fro motion of the bob of the pendulum is called one oscillation.
2. Period of oscillation or time period: It is the time taken to complete one oscillation. It is denoted by T. Its unit is second (s).

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3. Frequency of oscillation: It is the number of oscillations made in one second. It is denoted by f or n. Its unit is per second (s^{-1}) or hertz (Hz).
4. Frequency $f = \frac{1}{T}$
5. Amplitude: The maximum displacement of the bob from its mean position on either side is called amplitude of oscillation. It is denoted by a or A. Its unit is metre (m).
6. Effective length of the pendulum: It is the distance of the mean point of oscillation to the point of suspension. It is denoted as 1.

Measurement of time period of a simple pendulum

7. The time period is directly proportional to the square root of length.

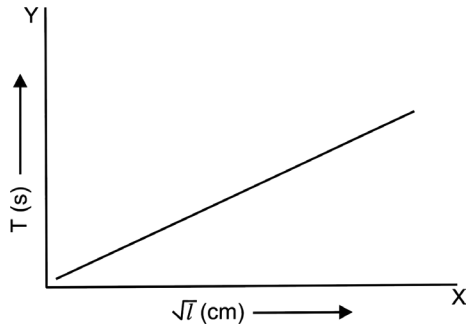
$$T \propto \sqrt{l}$$

$$T^2 \propto l$$

$$\frac{l}{T^2} = \text{constant}$$

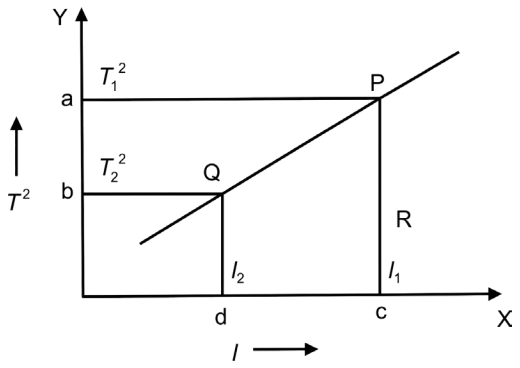
Graph of variation of time period T with length l

8. A graph of T v/s $\sqrt{l}$ is a straight line as shown below



Graph of T^2 v/s l

9. The graph of T^2 v/s l is a straight line indicating that T^2 is directly proportional to l for a pendulum.



10. The slope from the graph is given as SLOPE

$$= \frac{PR}{QR} = \frac{T_1^2 - T_2^2}{I_1 - I_2} = \frac{4\pi^2}{g}$$

Factors affecting time period

11. The time period of oscillation of a pendulum is directly proportional to .the square root of its effective length.

$$T \propto \sqrt{l}$$

12. The time period of oscillation of a pendulum is inversely proportional to the square root of acceleration due to gravity.

$$T \propto \frac{1}{\sqrt{g}}$$

13. The time period of oscillation of a pendulum does not depend on the mass or material of the body suspended.
14. The time period of oscillation of a pendulum does not depend on the extent of swing, that is, the amplitude on either side.
15. Thus, the time period of the pendulum is

$$T \propto 2\pi\sqrt{\frac{1}{g}}$$

Seconds pendulum

The pendulum in clocks is a seconds pendulum. This pendulum has a time period of 2 s.

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OBJECTIVE QUESTIONS

1. If an experimental laboratory pendulum flawlessly completes exactly 40 full oscillations within exactly one complete minute, what is its rigorously calculated scientific time period?
(A) 1.5 seconds
(B) 0.67 seconds
(C) 40 seconds
(D) 60 seconds

Ans : (A)

The total experimental duration equals exactly sixty seconds. To mathematically calculate the time required for a single complete oscillation, one must smoothly divide the total recorded sixty seconds by the forty observed oscillations. This straightforward calculation accurately yields one point five seconds.

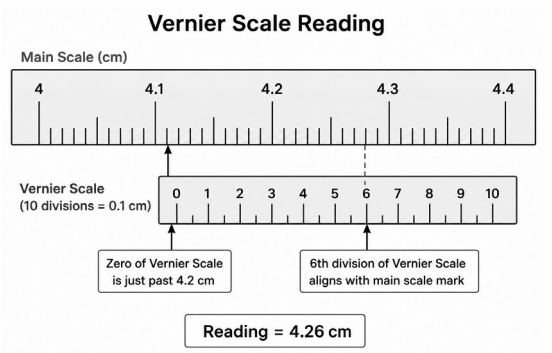
2. Which of the following pairs of derived physical quantities and their standard scientific units is fundamentally incorrect?
(A) Power – watt
(B) Force – newton

(C) Electric potential – volt
(D) Pressure – joule

Ans : (D)

Derived units strictly correspond to specific physical equations. Power is measured using watts, force uses newtons, and electric potential uses volts. Pressure is definitively measured in pascals, whereas the joule serves strictly as the fundamental derived unit for measuring energy.

3. A Vernier calliper, with a least count of 0.01 cm, is used to measure the length of an object. What is the reading shown in the diagram?


Vernier Scale Reading
Main Scale (cm)
4
4.1
4.2
4.3
4.4
Vernier Scale
(10 divisions = 0.1 cm)
0 1 2 3 4 5 6 7 8 9 10
Zero of Vernier Scale is just past 4.2 cm
6th division of Vernier Scale aligns with main scale mark
Reading = 4.26 cm

(A) 4.20 cm
(B) 4.26 cm
(C) 4.62 cm
(D) 4.80 cm

Ans : (B)

The main scale reading (MSR) is the reading on the main scale just before the zero of the Vernier scale, which is 4.2 cm. The coinciding Vernier division is the 6th. The Vernier scale reading (VSR) is the coinciding division multiplied by the least count: 6×0.01 cm $= 0.06$ cm. Total reading = MSR + VSR = 4.2 cm + 0.06 cm = 4.26 cm.

4. Which of the following correctly represents the numerical multiplicative factor for the prefix "nano"?
(A) 10^{-6}
(B) 10^{-9}
(C) 10^{-12}
(D) 10^{-15}

Ans : (B)

In scientific measurements, standard prefixes modify base units by specific multiplicative factors. The prefix nano strictly corresponds to one-billionth of a unit, mathematically expressed as ten raised to the power of negative nine. Micro represents one-millionth, while pico denotes one-trillionth.

5. What scientific term specifically describes the absolute maximum horizontal distance cleanly travelled by a swinging pendulum bob away from its perfectly central mean resting position?
(A) Total effective length
(B) Complete physical oscillation
(C) Maximum measured frequency
(D) Physical swinging amplitude

Ans : (D)

The precise mechanical definition of amplitude strictly refers to the absolute maximum spatial displacement reliably achieved by the metallic swinging bob on either extreme side of its vertical equilibrium rest position during one continuous complete standard mechanical laboratory oscillation cycle.

6. A highly accurate Vernier calliper features exactly twenty equal divisions distinctly marked upon its sliding Vernier scale. If the smallest available graduation on the fixed main scale is precisely 1 mm, what is the mathematically calculated least count of this instrument?
(A) 0.1 mm
(B) 0.05 mm
(C) 0.01 m
(D) 0.02 mm

Ans : (B)

The basic mechanical formula precisely defining the least count involves dividing the absolute value of one fundamental main scale division by the total count of Vernier divisions. Dividing exactly one millimetre by twenty directly yields an accurate least count of zero point zero five millimetres.

7. In the scientific study of an ideal simple pendulum's periodic motion, how is the "effective length" structurally defined?
(A) The total measured physical length of the entire flexible supporting thread.
(B) The exact physical diameter of the heavy metallic spherical bob attached at the bottom.
(C) The straight vertical distance between the rigid point of suspension and the exact centre of gravity of the bob.
(D) The absolute maximum horizontal displacement achieved by the pendulum bob from its central mean resting position.

Ans : (C)

A simple pendulum involves a massive point bob

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attached to an inextensible string. The highly critical effective length is scientifically measured starting directly from the absolute rigid point of suspension down precisely to the calculated centre of gravity inside the swinging metallic bob.

8. The table below outlines the base units for length and time in three different systems of measurement. Based on the established patterns for these systems, what is the correct unit of mass for the system labeled 'X'?

System	Base Unit of Length	Base Unit of Mass	Base Unit of Time
CGS	centimetre	gram	second
FPS	foot	pound	second
MKS	metre	X	second

(A) kilogram
(B) gram
(C) quintal
(D) pound

Ans : (A)

The question requires identifying the unit of mass in the MKS system. The acronym MKS stands for Metre-Kilogram-Second. Therefore, the base unit of mass in this system is the kilogram. The other options represent units of mass from different systems (gram in CGS, pound in FPS) or a multiple unit (quintal).

9. A newly manufactured precision screw gauge advances exactly 1 mm forward when carefully turned through exactly two complete continuous revolutions. If its rotating circular scale features exactly 50 distinct divisions, what is the definitive least count of this mechanical instrument?
(A) 0.01 mm
(B) 0.02 mm
(C) 0.005 mm
(D) 0.05 mm

Ans : (A)

Advancing precisely one millimetre over two complete rotations yields an exact pitch of zero point five millimetres. The essential least count is mathematically determined by dividing this calculated pitch by the fifty distinct circular divisions, accurately resulting in zero point zero one millimetres.

10. If a distinct particular colour of spectral light features a specific wavelength of 5890 angstroms, what is its exact calculated wavelength expressed in nanometres?
(A) 5.89 nm
(B) 58.9 nm
(C) 589 nm
(D) 58900 nm

Ans : (C)

One angstrom represents ten raised to the power of negative ten metres, while one nanometre equals ten raised to the power of negative nine metres. Therefore, one nanometre inherently contains exactly ten angstroms. Dividing the given angstrom value by ten accurately yields five hundred eighty-nine nanometres.

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11. While meticulously checking a precision screw gauge before an experiment, a student discovers the circular scale zero rests noticeably below the main scale baseline when the flat measuring ends meet. What specific type of zero error does this indicate?
(A) A completely uncorrectable random error.
(B) A perfectly precise negative zero error.
(C) A perfectly precise positive zero error.
(D) A severe mechanical backlash error.

Ans : (C)

When the distinct zero mark of the movable circular scale stops noticeably below the fixed main baseline after the mechanical jaws meet, a positive zero error effectively exists. The device prematurely registers a falsely positive numerical value before measurement even physically begins.

12. In a specific screw gauge featuring exactly 100 circular divisions and a least count of 0.001 cm, the 95th circular division aligns perfectly with the main baseline when the anvil and spindle touch. What is the mathematically calculated zero error?
(A) +0.005 cm
(B) -0.005 cm
(C) +0.095 cm
(D) -0.095 cm

Ans : (B)

Because the ninety-fifth division coincides with the baseline, the circular zero mark rests visibly above the horizontal baseline, clearly indicating a negative zero error. Subtracting ninety-five from one hundred leaves five divisions. Multiplying five by the least count yields negative zero point zero zero five centimetres.

13. **Assertion (A) :** An appropriately constructed second's pendulum completes exactly one full oscillation every single second.

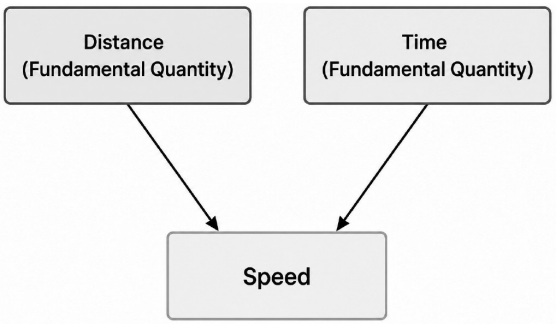
Reason (R) : A second's pendulum is scientifically defined as a simple pendulum possessing a definitively calculated time period of exactly two seconds.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (D)

A perfectly calibrated second's pendulum actually requires exactly two complete seconds to seamlessly finish one full oscillation cycle. It travels precisely from one extreme position back to the exact same position, meaning its established mathematical frequency evaluates exactly to zero point five hertz.

14. The diagram illustrates the relationship between physical quantities. What does this relationship signify about the quantity 'Speed'?



(A) Speed is a fundamental quantity derived from other fundamental quantities.
(B) Speed is a derived quantity dependent on the fundamental quantities of length and time.
(C) Speed is a fundamental quantity independent of length and time.
(D) Speed is a derived quantity that is used to define fundamental quantities.

Ans : (B)

The diagram shows that speed is obtained by combining the fundamental quantities of distance (length) and time. Quantities that are expressed in terms of two or more fundamental quantities are known as derived quantities. Therefore, speed is a derived quantity, not a fundamental one. The other options misinterpret this relationship.

15. Which of the following scientifically defines the massive astronomical unit known as a "parsec"?

(A) The total distance travelled by light passing through a complete vacuum in exactly one year.
(B) The precise distance at which an arc of length equal to one astronomical unit subtends an angle of one second.
(C) The average calculated distance between the central core of the Sun and the Earth.
(D) The physical amount of matter heavily contained within the entire mass of the Sun.

Ans : (B)

A parsec functions as an extremely large macroscopic unit of astronomical length. It represents the specific distance where an arc measuring exactly one astronomical unit perfectly subtends an angle of one second. One parsec numerically equals three point two six light years.

16. **Assertion (A) :** Force is classified as a derived physical quantity in the scientific measurement system.
Reason (R) : The unit of force can be mathematically expressed using the fundamental units of mass, length, and time.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Fundamental physical quantities possess completely independent units. Derived quantities depend directly on these fundamental base units. Force is calculated as mass multiplied by acceleration, meaning its unit is derived by mathematically combining the specific fundamental units of mass, length, and time together.

17. **Assertion (A) :** A carefully manufactured metre ruler can reliably measure standard linear physical distances with absolute accuracy strictly up to one millimetre.
Reason (R) : The smallest designated sub-division prominently engraved on a standard metric measuring scale is exactly one centimetre.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

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A standard metre ruler typically possesses ten distinct sub-divisions within every single measured centimetre. This precise graduation means that its smallest reliable measurable value, known as the instrument's least count, is exactly one millimetre, rendering the provided reasoning statement completely false.

18. How does the calculated least count of a measuring instrument primarily affect the final measurement process?

(A) A larger least count mathematically guarantees complete elimination of zero errors.
(B) A larger least count significantly increases the absolute precision of the final measurement.
(C) A smaller least count directly allows for a much more precise measurement.
(D) A smaller least count completely prevents any possible mechanical backlash errors.

Ans : (C)

The absolute precision of any physical measurement depends heavily upon the specific instrument utilised. A noticeably smaller least count firmly indicates that the measuring device can accurately detect significantly finer structural changes, thereby directly improving the overall experimental measurement precision.

19. A student is studying units of mass and compiles the following data. By analyzing the relationships within the table, determine how many times larger a solar mass is compared to a metric tonne.

Unit	**Value in kg**
Quintal	100
Metric Tonne	1,000
Solar Mass	2×10^{30}
Atomic Mass Unit	1.66×10^{-27}

(A) 2×10^{27}
(B) 2×10^{33}
(C) 5×10^{-28}
(D) 2×10^{-27}

Ans : (A)

To find how many times larger a solar mass is than a metric tonne, we must divide the value of a solar mass in kg by the value of a metric tonne in kg. This gives $(2 \times 10^{30}$ kg) / (1,000 kg)

$= (2 \times 10^{30}) / (10^{3})$

$= 2 \times 10^{(30-3)}$

$= 2 \times 10^{27}$.

20. Match the non-metric units of length to their standard numerical values expressed in metres.

List–I (Unit)
P. Angstrom
Q. Nanometre
R. Fermi
S. Micrometre

List–II (Value in metres)
I. 10^{-6} m
II. 10^{-9} m
III. 10^{-10} m
IV. 10^{-15} m

(A) P-III, Q-II, R-IV, S-I
(B) P-III, Q-IV, R-II, S-I
(C) P-II, Q-III, R-I, S-IV
(D) P-I, Q-II, R-IV, S-III

Ans : (A)

Non-metric units accurately measure microscopic atomic distances. An angstrom equals ten raised to negative ten metres. A nanometre represents ten raised to negative nine metres. A fermi equals ten raised to negative fifteen metres. A micrometre is exactly one-millionth of a metre.

21. Which of the following correctly describes the practical characteristics of a good scientific unit?

I. It must be completely independent of variations due to space and reference.
II. It should be easily reproducible for practical applications.
III. It must depend on varying physical environmental conditions.
IV. It is universally accepted by the global scientific community.

(A) I, II, and III are correct
(B) I, II, and IV are correct
(C) II, III, and IV are correct
(D) I, III, and IV are correct

Ans : (B)

A scientifically ideal unit of measurement must possess universal acceptance. It should remain entirely independent of physical variables like location or space. Furthermore, the unit must be non-perishable, of a highly convenient size, and easily reproducible for global laboratory applications.

22. **Assertion (A) :** The mass of microscopic atomic particles like protons and neutrons is measured in unified atomic mass units.
Reason (R) : One unified atomic mass unit is exactly equal to one-twelfth the mass of one single carbon-twelve atom.

(A) Both A and R are true and R is the correct

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explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Microscopic atomic particles possess extremely minute masses, making standard kilograms highly impractical. Scientists utilise the unified atomic mass unit for such microscopic precision. This specific standard is universally defined as precisely one-twelfth the mass of a single carbon-twelve atom.

23. The table provided shows SI prefixes used to denote submultiples of units. A value corresponding to the prefix 'nano' is missing. Determine the correct value for 'X' based on standard SI conventions.

Prefix	Symbol	Meaning (as a factor)
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	X
pico	p	10^{-12}

(A) 10^{-8}
(B) 10^{-9}
(C) 10^{-10}
(D) 10^{-11}

Ans : (B)

In the International System of Units (SI), standard prefixes are used to denote multiples and submultiples. The prefix 'nano' (symbol n) represents a factor of one billionth, which is mathematically expressed as 10^{-9}. This follows the standard progression of prefixes where each step (from micro to nano, nano to pico) changes by a factor of 1000.

24. Which carefully formulated statement regarding the practical physical construction and everyday laboratory operation of a standard micrometer screw gauge is scientifically incorrect?
(A) The barrel-shaped hollow sleeve securely carries the rigidly fixed main scale of the measuring device.
(B) The primary function of the rear ratchet is to confidently hold the physical object with gentle, predetermined slipping pressure.
(C) A severe backlash error fundamentally occurs due to physical mechanical wear and tear existing within the internal screw threads.
(D) A standard micrometer screw gauge operates relying upon the identical sliding friction principle actively utilised by Vernier callipers.

Ans : (D)

A micrometer fundamentally functions based completely upon the rotational mechanical principle of a screw, actively converting minute rotational motion into measurable linear axial displacement. Conversely, standard Vernier callipers strictly depend upon two distinct parallel linear sliding scales overlapping each other physically.

25. During careful initial calibration, if the measuring jaws of a Vernier calliper are shut tightly and the Vernier zero mark correctly rests visibly to the left of the main scale zero mark, what specific mechanical condition exists?
(A) The measuring instrument genuinely possesses a positive zero error.
(B) The measuring instrument genuinely possesses a negative zero error.
(C) The measuring instrument completely lacks any mechanical zero error.
(D) The measuring instrument suffers from an uncorrectable severe backlash error.

Ans : (B)

When closed jaws reveal the Vernier zero resting noticeably toward the left side of the fixed main scale zero, a negative zero error fundamentally exists. To achieve absolute mathematical accuracy, this measured negative error value must be carefully added to observed readings.

26. Regarding the calendar and measurement of time, which of the following statements are completely accurate?
I. Every year exactly divisible by four is always considered a leap year without any exceptions.
II. The year 2100 will not be counted as a valid leap year.
III. A lunar month is based on the moon's revolution around the Earth.
IV. A solar day is defined as the time taken by the Earth to complete one rotation on its axis.
(A) I, II, and III are correct
(B) II, III, and IV are correct
(C) I, III, and IV are correct
(D) I, II, and IV are correct

Ans : (B)

The English calendar specifically modifies standard leap year rules for century years.

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Century years must be strictly divisible by four hundred to qualify as leap years. Therefore, while regular years divisible by four are leap years, the year twenty-one hundred is definitely not.

27. Match the specific functioning parts of a standard Vernier calliper to their primary intended practical measurement functions.

List–I (Part)

P. Internal jaws
Q. External jaws
R. Vernier scale
S. Tail

List–II (Function)

I. Slides backward and forward to measure the depth of hollow test tubes.
II. Measures the outer external physical diameter of a solid metallic sphere.
III. Determines the precise inner internal diameter of a hollow cylindrical pipe.
IV. Slides cleanly over the fixed main scale to provide fractional millimeter readings.

(A) P-III, Q-II, R-IV, S-I
(B) P-II, Q-III, R-I, S-IV
(C) P-III, Q-I, R-IV, S-II
(D) P-I, Q-II, R-III, S-IV

Ans : (A)

Internal jaws carefully measure interior hollow cavities, while external jaws securely grip outside dimensions. The thin metallic tail explicitly measures the vertical depth of cylinders. The movable Vernier scale effortlessly slides across the main fixed scale, yielding highly refined measurement accuracy.

28. Which of the following statements precisely describe the mathematical principle and construction of a standard laboratory Vernier calliper?

I. The total length of ten Vernier scale divisions usually equals the length of nine main scale divisions.
II. One single Vernier scale division is mathematically larger than one main scale division.
III. The Vernier constant is uniquely calculated by subtracting one main scale division from one Vernier scale division.
IV. The least count is definitively the spatial difference between one main scale division and one Vernier scale division.

(A) I and III are correct
(B) I and IV are correct
(C) II and IV are correct
(D) II, III, and IV are correct

Ans : (B)

In standard mechanical Vernier callipers, ten distinct Vernier divisions precisely align with nine main scale divisions. Consequently, one Vernier division remains fractionally smaller than a main scale division. The absolute difference between these two distinct divisions forms the essential least count.

29. The table below lists four physical quantities. Which of these is a derived quantity, not a fundamental quantity in the SI system?

Quantity	SI Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Force	newton	N
Time	second	s

(A) Length
(B) Mass
(C) Force
(D) Time

Ans : (C)

In the SI system, there are seven fundamental quantities, which include length (metre), mass (kilogram), and time (second). Force is a derived quantity because its unit, the newton (N), is defined in terms of fundamental units as $kg \cdot m \cdot s^{-2}$. It is derived from the fundamental quantities of mass, length, and time.

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30. **Assertion (A) :** To obtain a perfectly accurate final reading from any given Vernier calliper, a properly calculated positive zero error must be rigorously added to the directly observed initial measurement.

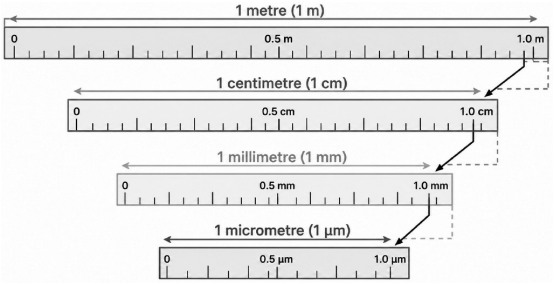
Reason (R) : A positive zero error mechanically indicates that the scientific instrument is prematurely reading a value marginally greater than absolute zero before any measurement begins.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (D)

A clearly positive zero error means the device mistakenly reads a small positive value when physically closed. Because the raw measurement inappropriately includes this excess fractional amount, the precisely determined positive zero error must logically be subtracted to discover the true physical dimension.

31. The diagram shows the relationship between different sub-multiples of a metre. Which option correctly arranges these units in ascending order of their value?



(A) 1 µm < 1 mm < 1 cm < 1 m
(B) 1 cm < 1 µm < 1 mm < 1 m
(C) 1 µm < 1 cm < 1 mm < 1 m
(D) 1 mm < 1 cm < 1 µm < 1 m

Ans : (A)

The units are related as follows: 1 metre (m) = 100 centimetres (cm), 1 cm = 10 millimetres (mm), and 1 mm = 1000 micrometres (µm). Therefore, the micrometre is the smallest unit shown, followed by the millimetre, then the centimetre, and finally the metre. The correct ascending order is µm, mm, cm, m.

32. Determine the correct chronological experimental sequence for scientifically measuring the diameter of a thin metallic wire using a standard precision screw gauge.

I. Carefully turn the ratchet head to gently move the flat spindle face toward the fixed anvil.
II. Determine the exact zero error of the device by bringing the anvil and spindle together.
III. Accurately note the final visible main linear scale reading.
IV. Find the specific value of one single linear scale division.
V. Place the thin metallic wire cleanly between the fixed anvil and moving spindle.

(A) II, IV, V, I, III
(B) IV, II, V, I, III
(C) I, II, V, IV, III
(D) V, I, II, III, IV

Ans : (A)

A scientifically rigorous measurement process begins by determining the fundamental zero error and calculating the instrument's basic linear division value. Subsequently, the specimen is safely inserted. The ratchet precisely closes the gap, allowing the researcher to accurately record the visible scale readings.

33. The following table provides the equivalent values of various units of length in metres. Based on the data, which option correctly arranges these units in ascending order of their magnitude?

Unit	Value in Metres (m)
Angstrom (Å)	10^{-10}
Fermi (fm)	10^{-15}
Nanometre (nm)	10^{-15}
Micrometre (µm)	10^{-6}

(A) Fermi < Angstrom < Nanometre < Micrometre
(B) Fermi < Nanometre < Angstrom < Micrometre
(C) Angstrom < Fermi < Nanometre < Micrometre
(D) Micrometre < Nanometre < Angstrom < Fermi

Ans : (A)

To arrange the units in ascending order, their values in metres must be compared. The powers of 10 are -15, -10, -9, and -6. A more negative exponent indicates a smaller value. Therefore, the correct ascending order is 10^{-15} (Fermi) < 10^{-10} (Angstrom) < 10^{-9} (Nanometre) < 10^{-6} (Micrometre), making option A the correct sequence.

34. Which carefully stated definition most accurately describes the mechanical 'pitch' of a standard precision screw gauge?

(A) The exact number of equally spaced divisions visibly engraved around the outer circumference of the circular thimble.
(B) The total measurable fractional distance cleanly covered by one individual division of the rotating circular scale.
(C) The straight linear axial distance effectively travelled by the internal screw during one complete three-hundred-sixty-degree mechanical rotation.
(D) The completely unhindered straight linear

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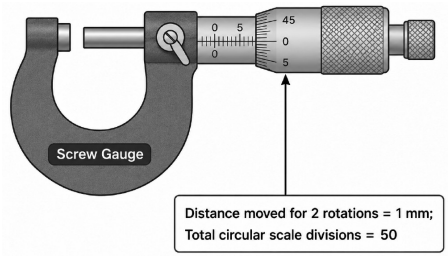
distance between the fixed rigid anvil and the movable threaded spindle.

Ans : (C)

The foundational mechanical principle of a screw gauge relies heavily upon the rotational translation of threads. The pitch strictly defines the absolute linear axial distance covered by the threaded screw when the rotating circular head completes exactly one full spatial revolution.

35. For the screw gauge shown, the screw moves 1 mm for two full rotations of the circular scale, which has 50 divisions. What is the least count of this instrument?



(A) 0.01 mm
(B) 0.02 mm
(C) 0.05 mm
(D) 0.50 mm

Ans : (A)

Explanation: First, calculate the pitch, which is the distance moved in one rotation. Pitch = 1 mm / 2 rotations = 0.5 mm. The least count is the pitch divided by the number of circular scale divisions. Least Count = Pitch / No. of divisions = 0.5 mm / 50 = 0.01 mm. This is the smallest value the instrument can accurately measure.

36. Which of the following experimental techniques represent mathematically valid methods for intentionally decreasing the least count of a precision screw gauge, thereby notably increasing its inherent measurement accuracy?

I. Significantly increasing the established pitch of the internal screw mechanism.
II. Significantly decreasing the established pitch of the internal screw mechanism.
III. Noticeably increasing the total numerical count of equally spaced divisions marked upon the rotating circular scale.
IV. Noticeably decreasing the total numerical count of equally spaced divisions marked upon the rotating circular scale.

(A) I and III are correct
(B) II and III are correct
(C) I and IV are correct
(D) II and IV are correct

Ans : (B)

The mathematical least count equals the established pitch directly divided by the total circular divisions. To effectively shrink this ultimate fractional value, manufacturers must intelligently reduce the mechanical pitch distance or substantially expand the total number of divisions featured on the circular scale.

37. To actively prevent the frustrating physical occurrence of mechanical backlash error while operating a precision screw gauge during a laboratory experiment, what specific operational procedure should a careful student logically adopt?

(A) They should rapidly forcefully rotate the thimble back and forth continually.
(B) They should rigorously ensure the internal screw is only rotated smoothly in one single consistent direction.
(C) They should heavily lubricate the circular scale divisions with thick industrial mechanical oil.
(D) They should carefully remove the ratchet mechanism completely from the outer hollow cylindrical tube.

Ans : (B)

Backlash errors fundamentally stem from loose worn internal threads temporarily failing to engage properly. By maintaining a single continuous direction of rotation without suddenly reversing, the internal threads remain firmly engaged, effectively preventing the internal screw from remaining briefly and incorrectly stationary.

38. Regarding the fundamental scientific factors definitively affecting the time period of a simple pendulum, which of the following statements represent universally established physical truths?

I. The time period strongly depends upon the elemental material composing the massive metallic bob.
II. The time period is mathematically directly proportional to the square root of its measured effective length.
III. The time period remains completely independent of the pendulum's swinging amplitude, provided the amplitude remains relatively small.
IV. The time period is mathematically directly proportional to the local acceleration due to Earth's gravity.

(A) II and III are correct

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(B) I and IV are correct
(C) II and IV are correct
(D) I, II, and III are correct

Ans : (A)

A pendulum's precise periodic time is strictly dictated by its effective length and the surrounding gravitational acceleration field. It remains absolutely unaffected by the bob's material mass or its swing amplitude, strictly assuming the swinging angular displacement remains within mathematically small operational limits.

39. The table shows data from an experiment with a simple pendulum, where the time for 20 oscillations was recorded for different lengths. The time period (T) for a length of 81 cm is missing (marked as 'X'). Calculate the value of X.

Length (l) in cm	**Time for 20 oscillations (t) in s**	**Time Period T = t/20 (s)**
49	28	1.4
64	32	1.6
81	36	X
100	40	2.0

(A) 1.7 s
(B) 1.8 s
(C) 1.9 s
(D) 36.0 s

Ans : (B)

The time period (T) of a pendulum is the time taken for one complete oscillation. It is calculated by dividing the total time taken (t) by the number of oscillations. For a length of 81 cm, the time for 20 oscillations is 36 s. Therefore, the time period T = 36 s / 20 = 1.8 s.

40. If an experimental physicist carefully plots the square of the time period (T^2) against the effective length (l), the definitively calculated slope of the resulting straight-line graph perfectly equals:

(A) $\frac{4\pi^2}{g}$

(B) $\frac{g}{4\pi^2}$

(C) $\frac{2\pi}{g}$

(D) $\frac{g}{2\pi}$

Ans : (A)

The established formula linking a pendulum's time period is T equals two pi multiplied by the square root of length divided by gravity. Squaring this foundational formula directly demonstrates that the proportional graphical slope cleanly reduces to precisely four pi squared divided by gravity.

41. Why does a classic metallic pendulum clock inherently begin ticking noticeably slower during extremely hot summer months?
(A) The dense metal bob physically loses overall mass due to intense extreme surface evaporation.
(B) The flexible metallic string expands thermally, thereby increasing the pendulum's effective length and corresponding time period.
(C) The surrounding atmospheric environmental air friction significantly increases, slowly retarding the continuous swinging motion.
(D) The local acceleration due to gravity mathematically decreases rapidly because of rising surface temperatures.

Ans : (B)

Elevated seasonal temperatures naturally cause internal metallic components to undergo significant thermal physical expansion. This inevitable stretching gradually increases the pendulum's overall effective length. A longer pendulum logically demands more time to successfully complete an oscillation, causing the mechanical clock to tick slower.

42. If a properly functioning, highly accurate pendulum clock is physically relocated from sea level to the high-altitude peak of a massive mountain, what precisely happens to its standard timekeeping?
(A) It begins ticking noticeably faster because the gravitational acceleration mathematically increases at elevated high altitudes.
(B) It begins ticking noticeably slower because the gravitational acceleration mathematically decreases at elevated high altitudes.
(C) It continues maintaining completely perfect accurate time because time period remains entirely independent of gravitational acceleration.
(D) The pendulum instantly stops swinging completely due to drastically lowered atmospheric air pressure conditions.

Ans : (B)

The essential periodic time of any swinging pendulum remains fundamentally inversely

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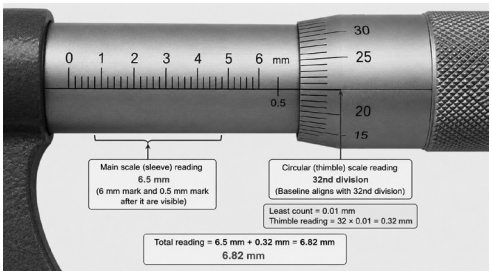
proportional to the square root of the surrounding gravitational acceleration. Because gravity noticeably weakens at elevated mountain altitudes, the pendulum requires a longer duration per swing, making the clock noticeably lose time.

43. An experimental laboratory pendulum currently measuring 25 cm strictly possesses a carefully verified time period of precisely 1.0 s. If its effective length is intentionally increased to 100 cm, what mathematically becomes its newly calculated time period?
(A) 2.0 s
(B) 4.0 s
(C) 0.5 s
(D) 1.5 s

Ans : (A)

A simple pendulum's periodic time strictly varies in direct mathematical proportion to the square root of its length. When the experimental length is multiplied by a massive factor of four, the corresponding time period directly increases by a factor of precisely two.

44. A screw gauge is used to measure the diameter of a thin wire. Based on the reading shown in the diagram, what is the diameter? (Least Count = 0.01 mm)


0 1 2 3 4 5 6 mm
0.5
30
25
20
15
Main scale (sleeve) reading
6.5 mm
(6 mm mark and 0.5 mm mark after it are visible)
Circular (thimble) scale reading
32nd division
(Baseline aligns with 32nd division)
Least count = 0.01 mm
Thimble reading = 32 × 0.01 = 0.32 mm
Total reading = 6.5 mm + 0.32 mm = 6.82 mm
6.82 mm

(A) 6.32 mm
(B) 6.53 mm
(C) 6.82 mm
(D) 7.32 mm

Ans : (C)

Explanation: The main scale reading (MSR) is the last fully visible division on the sleeve, which includes the 0.5 mm marks. Here, the reading is 6.5 mm. The coinciding circular scale division is 32. The circular scale reading (CSR) is 32×0.01 mm $= 0.32$ mm. The total diameter is MSR + CSR $= 6.5$ mm $+ 0.32$ mm $= 6.82$ mm.

45. Which given statement definitively represents the most scientifically accurate physical definition of a standard derived unit?
(A) A standard unit possessing its own independent elementary physical scientific value.
(B) A standard unit exclusively reserved for strictly measuring massive astronomical celestial distances.
(C) A standard unit mathematically formed by intelligently combining two or more fundamental base units.
(D) A standard unit uniquely determined by dividing the given physical mass by the measured time.

Ans : (C)

The internationally accepted scientific measurement system sharply distinguishes exactly seven fundamental base units. Any distinct physical unit carefully constructed by mathematically multiplying or dividing these specific foundational units is formally officially classified within physics as a mathematically derived measurement unit.

46. Which of the following measuring devices fundamentally provides the absolute highest level of reliable accuracy for carefully recording extremely short sequential time intervals within a modern scientific laboratory?
(A) A classic mechanical swinging pendulum clock.
(B) A standard mechanical wind-up stop clock.
(C) A modern highly precise electronic stopwatch.
(D) A standard wall-mounted analogue quartz clock.

Ans : (C)

While both stop clocks and stopwatches fundamentally rely upon the periodic mechanical motion of a balance wheel, a properly calibrated stopwatch features significantly advanced internal precision. It possesses a notably smaller reliable least count, making it significantly more accurate for scientific laboratory interval measurements.

47. A solid rectangular glass slab carefully features a measured length of 50 cm, a breadth of 20 cm, and a height of 2.5 cm. What is the rigorously calculated structural volume of this glass slab properly expressed in standard SI units?
(A) 2500 m^3
(B) 2.5 m^3
(C) 0.025 m^3
(D) 0.0025 m^3

Ans : (D)

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First, accurately multiply the given raw dimensions: fifty centimetres times twenty centimetres times two point five centimetres naturally equals twenty-five hundred cubic centimetres. To safely convert into standard cubic metres, carefully divide by one million, yielding accurately zero point zero zero two five cubic metres.

48. Why does the periodic physical swinging rate of a typical playground swing visibly naturally accelerate whenever an individual actively stands up entirely straight upon the wooden seat?

(A) The standing person's overall total physical body mass fundamentally magically increases.
(B) The standing person significantly forcibly pushes the wooden swing with substantially more muscular energy.
(C) The individual's distinct bodily centre of gravity elevates, scientifically decreasing the system's overall effective length.
(D) The local physical gravitational pull mathematically noticeably amplifies precisely when an individual stands up straight.

Ans : (C)

The precise time period of a swinging system fundamentally depends securely upon its measured effective length. Standing significantly raises the physical centre of gravity, which dynamically shortens the essential effective length. Consequently, the pendulum rigorously mathematically completes subsequent oscillations considerably faster.

49. Which carefully formulated mathematical definition perfectly describes the concept of a measured absolute error within scientific laboratory data analysis?

(A) The straightforward mathematical ratio of the mean absolute error cleanly divided by the accurately measured quantity.
(B) The exact mathematical difference cleanly separating an object's true theoretical physical value from its experimentally measured value.
(C) The precise arithmetic geometric average of all calculated magnitudes of errors within a recorded physical experiment.
(D) The strictly percentage-based mathematical calculation of standard deviations across a full physical scientific dataset.

Ans : (B)

In rigorous scientific data evaluation, the absolute measurement error definitively quantifies the exact mathematical discrepancy distinctly separating the officially recognised true theoretical physical value from the specific numerical value carefully extracted during the actual experimental scientific laboratory measurement process testing.

50. When experimental laboratory data from a simple pendulum is carefully plotted with the time period (T) on the Y-axis and the effective length (l) on the X-axis, what specific geometric shape does the resulting visual graph naturally form?

(A) A completely straight linear line directly passing precisely through the origin.
(B) A distinctly curved non-linear graphical line.
(C) A completely flat horizontal straight line running perfectly parallel to the X-axis.
(D) A completely straight vertical line running perfectly parallel to the Y-axis.

Ans : (B)

The mathematical time period strictly varies in direct proportion to the square root of the pendulum's effective length. Plotting the raw time period directly against the un-squared length inherently produces a visibly curved geometric line rather than a mathematically simple proportional straight line.

51. Which carefully stated scientific rule regarding the proper rigorous formatting of SI units is fundamentally grammatically incorrect?

(A) An accepted symbol for any unit specifically named after a famous scientist must uniquely begin with a capital uppercase letter.
(B) The full written name of any scientific unit should properly commence with a small lowercase letter, entirely regardless of its historical origin.
(C) Accepted scientific unit symbols must always remain physically unaltered when expressing multiple plural quantities.
(D) A clearly visible grammatical full stop must be strictly appended directly after every single written scientific unit symbol.

Ans : (D)

Standard internationally agreed conventions explicitly forbid appending punctuation marks directly after scientific unit symbols, primarily because these distinct symbols uniquely represent strict mathematical entities rather than simple linguistic abbreviations. Pluralization of symbols and capitalising non-scientist unit symbols are similarly strictly forbidden experimentally.

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ONE MARK QUESTIONS

52. Name the three fundamental quantities.

Ans :
Three fundamental quantities are : mass, length and time.

53. What is meant by measurement ?

Ans :
Measurement is the process of comparing a physical quantity with a standard unit.

54. What is the S.I. unit of Luminous intensity?

Ans :
The SI unit of luminous intensity is the candela (cd).

55. What is a seconds' pendulum ?

Ans :
A seconds' pendulum is a simple pendulum whose time period is 2 seconds.

56. Define standard metre.

Ans :
Metre (m) is defined as "the distance travelled by light in $\frac{1}{299792458}$ th second."

57. How is nanometre is related to Angstrom ?

Ans :
$1\text{nm} = 10\mathring{A}$

58. What is a leap year ?

Ans :
A year which has 366 days and in which the month of February has 29 days.

59. The year 2024 will have February of 29 days. Is this statement true ?

Ans :
Yes, the year 2024 is divisible by 4 and hence month February will have 29 days.

60. How are the time period T and frequency f of an oscillation of simple pendulum related ?

Ans :
The time - period of a simple pendulum is the reciprocal of its frequency (f).

61. State one use of a screw gauge.

Ans :
The screw gauge is used to measure the diameter of a wire or thickness of a paper.

62. What do you understand by the term unit ?

Ans :
A unit is a fixed and standard quantity used to measure a physical quantity. It provides a reference to express the magnitude of that quantity.

63. How is a physical quantity expressed?

Ans :
A physical quantity is typically expressed using a combination of a numerical value and a unit of measurement.

64. Define one parsec.

Ans :
One parsec is the distance at which one astronomical unit (AU) subtends an angle of one second of arc.

65. Define the pitch of a screw gauge.

Ans :
The pitch of a screw is the distance moved along its axis by the screw in one complete rotation of its head.

66. State the purpose of ratchet in a screw gauge.

Ans :
It ensures uniform pressure while taking measurements and prevents over-tightening, giving accurate readings.

67. Which of the following measures a small length to a high accuracy :
metre ruler, vernier callipers, screw gauge ?

Ans :
Screw gauge.

68. Define a derived unit.

Ans :
A derived unit is a unit that is obtained by combining two or more fundamental units.
The unit of force (newton) is a derived unit because

$$\text{Force} = \text{mass} \times \text{acceleration},$$

so its unit is $\text{kg}\cdot\text{m}/\text{s}^2$.

69. What is a lunar month ?

Ans :
A lunar month is the time taken by the Moon to complete one cycle of phases (from new moon to new moon), which is about 29.5 days.

70. Define 'amplitude of oscillation'.

Ans :

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Amplitude of oscillation is the maximum displacement of a vibrating or oscillating body from its mean (equilibrium) position.

71. Name two factors on which the time period of a simple pendulum does not depend.

Ans :
The time - period of a simple pendulum does not depend upon the following factors :
(i) mass of the bob
(ii) amplitude of oscillation

72. Define the least count of an instrument.

Ans :
The least count of an instrument is the smallest measurement that can be taken accurately with it.

73. How can you decrease the least count of a vernier callipers?

Ans :
The least count of a vernier callipers can be decreased by increasing the total number of divisions on vernier scale.

74. Define the term 'Vernier constant."

Ans :
Vernier constant"of a vernier is equal to the difference between the values of one main scale division (M.S.D) and one vernier scale division (V.S.D)" It is also called least count of the vernier scale.

75. When is a vernier callipers said to be free from zero error ?

Ans :
On bringing the movable jaw in contact with the fixed jaw, the zero mark of the vernier scale should coincide with the zero mark of the main scale. If it is so, the vernier is said to be free from zero error.

76. State the difference between positive and negative zero error of a vernier callipers.

Ans :
Positive zero error: Vernier zero is to the right of main scale zero; subtract the error.
Negative zero error: Vernier zero is to the left of main scale zero; add the error.

77. How can the least count of a screw gauge be decreased?

Ans :
The least count of a screw gauge can be decreased by
(i) decreasing the pitch and
(ii) increasing the total number of divisions on the circular scale.

78. A boy measures the length of a pencil and expresses it to be 2.6 cm. What is the accuracy of his measurement? Can he write it as 2.60 cm ?

Ans :
The accuracy of his measurement is 1 mm (0.1 cm).
No, he could not write it as 2.60 cm as there are only 10 count in 1 cm on metre rule.

79. State the difference between positive and negative zero error of a screw gauge.

Ans :
Positive zero error: Zero of circular scale is below the reference line; subtract the error.
Negative zero error: Zero of circular scale is above the reference line; add the error.

80. Name the S.I. unit of mass and define it.

Ans :
S.I. unit of mass is 'kilogramme'.
Kilogramme is defined as "the mass of a platinum-iridium cylinder kept at the International Bureau of Weights and Measures at Serves near Paris, France."

81. One parsec is the distance at which one astronomical unit (AU) subtends an angle of one second of arc.

Ans :
A fundamental or basic unit is that which is independent of any other unit or which can neither be changed nor can be related to any other fundamental unit. *e.g.* units of mass, length, time and temperature.

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82. State the numerical value of the frequency of oscillation of a seconds' pendulum. Does it depend on the amplitude of oscillation?

Ans :

$$\text{Frequency} = \frac{1}{T}$$

and T for seconds' pendulum is 2 seconds 1

$$\text{Frequency} = \frac{1}{2} = 0.5\, s^{-1}$$

Oscillation of pendulum does not depend on amplitude.

TWO MARKS QUESTIONS

83. Explain the meaning of the term 'least count of an instrument' by taking a suitable example.

Ans :
Least count 'of an instrument is the smallest measurement that can be taken accurately with it.' Least count of a metre rule is the value of its one division which is 1 mm. Least count of a vernier callipers is 0.1 mm and that of screw gauge is 0.01 mm.

84. Name two units of time bigger than a second. How are they related to the second ?

Ans :
Two bigger units of time are (a) Day (b) Year.

Relation 1 Day = 86400 seconds

1 Year = 3.1536 x 107 seconds.

85. What are the three requirements for selecting a unit of a physical quantity ?

Ans :
Three requirements for selecting a unit are
(i) The unit should be reproducible.
(ii) It should be possible to define the unit without ambiguity.
(iii) The value of unit should not change with space and time.

86. Name two units of length which are bigger than a metre. How are they related to the metre ?

Ans :
Bigger units of length are :
(i) Astronomical unit (A.U.) : The distance between the earth and the sun is called A.U. 1 A.U. $= 1.5 \times 10^{11}$m.
(ii) Light year (1y) : The distance travelled by light in one year.
1 Light year $= 9.46 \times 10^{15}$.

87. Name the S.I. unit of time and define it.

Ans :
S.I. unit of time is second (s).
Second. "A second is defined as $\frac{1}{86400}$ th part of a mean solar day."
Second may also be defined "as to be equal to the duration of 9,192,631,770 vibrations corresponding to the transition between two hyperfine levels of caesium - 133 atom in the ground state."

88. Name the three convenient units used to measure length ranging from very short to very long value. How are they related to the S.I. unit ?

Ans :
Three units used to measure length ranging from very short to very long are (a) micron (b) metre (c) angstroms.

$$\text{Micron} = 1\mu m = 10^{-6}m$$
$$1\mathring{A} = 10^{-10}m$$

Relation $1m = 10^6$ micron $= 10^{10}\mathring{A}$

89. State two units of mass smaller than a kilogram. How are they related to the kilogram ?

Ans :
Smaller units of mass are (a) gram(g)
(b) milligram (mg)
Relation with kg

$$1\text{mg} = 10^{-6}\text{kg}$$

or $1\text{kg} = 10^6\text{mg}$

$$1g = 10^{-3}\text{kg}$$

or $1\text{kg} = 10^3 g$

90. State two units of mass bigger than a kilogram. Give their relationship with the kilogram.

Ans :
The bigger units of mass are (i) quintal and (ii) metric tonne.

Relation 1 quinta = 100 kg

1 metric tonne = 1000 kg

1 quintal = 100 kg

1 metric tonne = 1000 kg

$= 100 \times 10 = 10$ quintal.

91. Name the instrument which can measure accurately the following :
(a) The diameter of a needle.
(b) The thickness of a paper.
(c) The internal diameter of the neck of a water bottle.
(d) The diameter of a pencil.

Ans :
(a) Screw gauge.
(b) Screw gauge.
(c) Vernier callipers.
(d) Screw gauge.

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92. Name the part of the vernier callipers which is used to measure the following :
(a) External diameter of tube,
(b) Internal diameter of a mug,
(c) Depth of a small bottle,
(d) Thickness of a pencil.

Ans :
(a) Outside jaws
(b) Inside jaws
(c) Strip
(d) Outside jaws

93. What is a simple pendulum ? Is the pendulum used in a pendulum clock simple pendulum ? Give reason to your answer.

Ans :
A simple pendulum consists of a heavy point mass (called bob) suspended from a rigid support by a massless, inextensible string.
No. The pendulum used in a pendulum clock is a compound pendulum, which is a body capable of oscillating about a horizontal axis passing through it.

94. Two simple pendulums A and B have equal lengths, but their bobs weigh 50 gf and 100 gf respectively. What would be the ratio of their time periods ? Give reason for your answer.

Ans :
We know that time period of simple pendulum at a place is given by $T = 2\pi\sqrt{\frac{l}{g}}$ ...(i)
and this expression does not contain weight of bob i.e. is independent of the weight of bob.
Time period of both pendulums will be same.
Ratio of their time periods = 1 : 1

95. Name the instrument which has the least count :
(a) 0.1 mm
(b) 1 mm
(c) 0.01 mm.

Ans :
(a) The instrument used to measure least count of 0.1 mm is vernier callipers.
(b) The instrument used to measure the least count of 1 mm is metre scale.
(c) The instrument used to measure the least count of 0.01 mm is screw gauge.

96. Complete the following :
(a) 1 light year = ...
(b) 1 m = ... $\mathring{A}$
(c) 1 m = ... μ (micron)
(d) 1 micron = ... $\mathring{A}$
(e) 1 fermi = ... m

Ans :
(a) light year $= 9.46 \times 10^{15}$ m
(b) 1 m $= 10^{10}\mathring{A}$
(c) 1 m $= 10^{6}\mu$ (micron)
(d) 1 micron $= 10^{4}\mathring{A}$
(e) 1 fermi $= 10^{-15}$ m

97. Complete the following :
(a) 1 g = ... kg
(b) 1 mg = ... kg
(c) 1 quintal = ... kg
(d) 1 a.m.u. (or u) = ... kg

Ans :
(a) 1 g $= 10^{-3}$ kg
(b) 1 mg $= 10^{-6}$ kg
(c) 1 quintal = 100 kg
(d) 1 a.m.u. (or u) $= 1.66 \times 10^{-27}$ kg

98. Complete the following :
(a) 1 nano second = ... s.
(b) $1\mu s$ = ... s.
(c) 1 mean solar day = ... s.
(d) 1 year = ... s.

Ans :
(a) 1 nano second $= 10^{-9}s$.
(b) $1\mu s$ $= 10^{-6}s$.
(c) 1 mean solar day $= 86400s$.
(d) 1 year $= 3.1536 \times 10^{7}s$.

99. Name the physical quantities which are measured in the following units :
(a) u
(b) ly
(c) ns
(d) nm

Ans :
(a) Mass
(b) Distance (or length)
(c) Time
(d) Length

100. Name the physical quantities related to the following units :
(a) km^2

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(b) Newton
(c) Joule
(d) Pascal
(e) Watt

Ans :
(a) km^2 — area
(b) newton — force
(c) joule — energy
(d) pascal — pressure
(e) watt — power

101. State how does the time period of a simple pendulum depend on
(a) length of pendulum,
(b) mass of bob,
(c) amplitude of oscillation and
(d) acceleration due to gravity.

Ans :
The time - period of a simple pendulum is :
(a) directly proportional to square root of its length.
(b) independent of mass of bob.
(c) independent of amplitude of oscillation.
(d) inversely proportional to the square root of acceleration due to gravity.

102. A boy makes a ruler with graduations in cm on it (i.e., 100 division in 1m). To what accuracy this ruler can measure? How can this accuracy be increased ?

Ans :
Accuracy : The ruler has 100 divisions in 1 m, so each division is 1 cm. Therefore, it can measure lengths accurately up to 1 cm (0.01 m).
Increase in accuracy : The accuracy can be increased by making smaller divisions on the ruler (such as millimetres). It can also be improved by using more precise instruments like a vernier calipers or micrometer screw gauge.

103. Two simple pendulums A and B have lengths 1.0 m and 4.0 m respectively at a certain place. Which pendulum will make more oscillations in 1 minute ? Explain your answer.

Ans :
Time period of simple pendulum at a place is given by

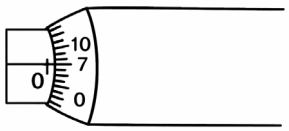
$$T = 2\pi\sqrt{\frac{l}{g}} \text{ i.e. } T \propto \sqrt{l}$$

A pendulum with smaller length will have smaller time period i.e. it will complete oscillation in lesser time. Hence it will make more oscillations in 1 minute. Since length of pendulum A is $\frac{1}{4}$th of the length of pendulum B. Pendulum A will make more oscillations.

THREE MARKS QUESTIONS

104. A screw gauge has a least count 0.001 cm and zero error + 0.007 cm. Draw a neat diagram to represent it.

Ans :



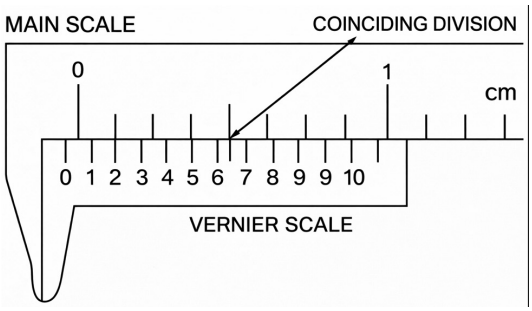
Positive zero error (error + 0.007 cm)

105. What is backlash error ? Why is it caused ? How is it avoided?

Ans :
Sometimes due to wear and tear of threads of screw, it is seen that on reversing the direction of rotation of the thimble, the tip of the screw does not start moving in the opposite direction immediately, but remains stationary for a part of rotation. This is called the backlash error. To avoid the backlash error while taking the measurements, the screw should be rotated in one direction only.

106. A vernier callipers has a zero error + 0.06 cm. Draw a neat labelled diagram to represent it.

Ans :



107. How do you measure the time period of a given pendulum ? Why do you note the time for more than one oscillation ?

Ans :
To measure the time - period of a given pendulum,

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the bob is slightly displaced from its mean position and is then released. It begins to move to-and-fro about its mean position in a vertical plane along with the string. Now time (t) for 20 complete oscillations is noted with the help of a stop watch. t is then divided by 20 to obtain time period (T). Time for number of oscillations more than 1 is noted because least count of stop watch is either 1 s or 0.5 s. It can not record the time period 0.2 s or 1.3 s or 1.4 s etc. It is made possible by noting the time for 20 oscillations or more than it.

108. State three uses of a vernier callipers.

Ans :

The three uses of a vernier calliper are as follows :

(i) The upper jaws called the inside jaws are used to measure the internal diameter of a hollow cylinder or pipe.

(ii) The lower jaws called the outside jaws are used to measure the length of a rod, diameter of the sphere or external diameter of a cylinder.

(iii) A thin long strip T attached to the vernier strip at the back of the main scale strip is used to measure the depth of a small beaker or bottle.

109. Explain the terms

(i) pitch, and

(ii) least count of a screw gauge.

How are they determined ?

Ans :

(i) The pitch of a screw is the distance moved by the screw in one complete rotation of its head."

Pitch may also be defined as "the distance between two consecutive threads of screw measured along the axis of screw."

$$\text{Pitch} = \frac{\text{Distance moved by thimble on M.S.}}{\text{Number of rotations of thimble}}$$

(ii) The least count of a screw gauge is the distance moved by its screw in rotating the circular scale by one division.

$$\text{L.C.} = \frac{\text{Pitch of screw}}{\text{Total number of divisions on head scale}}$$

110. Name of two scales of a vernier callipers and explain, how is it used to measure a length correct up-to 0.01 cm.

Ans :

The two scales of a vernier callipers are :

(i) Main scale, which is fixed

(ii) Vernier scale, which slides along the main scale.

The main scale is graduated with value of one division on it equal to 1 mm. The graduations of a vernier scale are such that the length of n divisions on vernier scale is equal to length of $(n-1)$ divisions of main scale.

Generally, a vernier scale has 10 divisions and the length of these divisions is equal to the length of (10 — 1) = 9 divisions of main scale. Thus each division of a vernier scale is smaller in size by $\frac{1}{10}$ mm or 0.01 cm than a division on the main scale.

This principle is used to measure a length correct upto 0.01 cm.

FOUR MARKS QUESTIONS

111. Name two factors on which the time period of a simple pendulum depends. Write the relation for the time period in terms of the above named factors.

Ans :

Factors on which time period of a simple pendulum depends :

$$T = 2\pi\sqrt{\frac{l}{g}} \text{ depends :}$$

(i) $T \propto \sqrt{l}$ or $T^2 \propto 1$

i.e.,if length increases, time period increases. That is why in summer pendulum of clock goes slow.

(ii) $T \propto \frac{1}{\sqrt{g}}$.That is why when clock is taken to a Mountain where 'g' decreases with altitude, time period increases and pendulum takes more time to complete an oscillation and hence the clock goes slow.

(iii) Mass or material of bob : Time period of simple pendulum is independent of mass.

(iv) Amplitude : Time period of simple pendulum is independent of amplitude. So long as swing is not too large.

Relation: $T = 2\pi\sqrt{\frac{l}{g}}$

112. How is the time period of a simple pendulum affected, if at all, in the following situations :

(a) the length is made four times.

(b) the acceleration due to gravity is reduced to one-fourth.

Ans :

(a) The length is made four times : We know that time period of simple pendulum

$$T = 2\pi\sqrt{\frac{l}{g}}$$

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Change length to $4l$

$$T' = 2\pi\sqrt{\frac{4l}{g}} = 2 \times 2\pi\sqrt{\frac{l}{g}}$$

$$T' = 2T \qquad \text{from (i)}$$

Time period is doubled.

(b) Acceleration due to gravity is reduced to one - fourth :

$$T = 2\pi\sqrt{\frac{l}{g}} \qquad ...(i)$$

New value of gravity $= \frac{g}{4}$

New item period $T' = 2\pi\sqrt{\frac{l}{g/4}}$

$$= 2\pi\sqrt{\frac{4l}{g}}$$

or $T' = 2 \times 2\pi\sqrt{\frac{l}{g}}$ from (i)

$$T' = 2T$$

Time period is doubled.

113. What are the fundamental units in S.I. system ? Name them along with their symbols.

Ans :

In S.I. there are seven fundamental units and two supplementary units :

(a) Fundamental units :

S. No.	Physical quantity	Name	Symbol
1.	Mass	kilogramme	kg
2.	Length	metre	m
3.	Time	second	s
4.	Temperature	kelvin	K
5.	Luminous intensity	candela	cd
6.	Electric current	ampere	A
7.	Quantity of matter	mole	mol

(b) Supplementary units :

1.	Plane Angle	radian	rad
2.	Solid Angle	steradian	sr

114. Explain the meaning of derived unit with the help of one example.

Ans :

Derived units are those which can be expressed in terms of fundamental units.

Example.

$$\text{Force} = \text{mass} \times \text{acceleration}$$

$$= \text{mass} \times \frac{\text{velocity}}{\text{time}}$$

$$= \text{mass} \times \frac{\frac{\text{distance}}{\text{time}}}{\text{time}}$$

$$= \frac{\text{mass} \times \text{distance}}{(\text{time})^2}$$

$$= \text{mass} \times \frac{\frac{\text{distance}}{\text{time}}}{\text{time}}$$

$$= \frac{\text{mass} \times \text{distance}}{(\text{time})^2}$$

$$\text{force} = \frac{\text{mass} \times \text{length}}{(\text{time})^2}$$

115. Draw a neat diagram of a simple pendulum. Show on it the effective length of the pendulum and its one oscillation.

Ans :

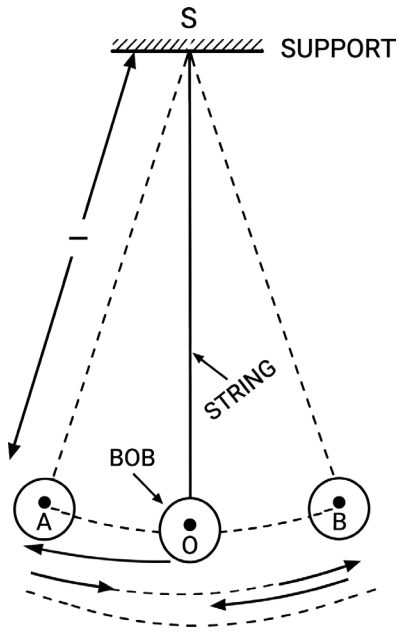

Figure : Simple Pendulum

One complete to and fro motion of the pendulum is called one oscillation. In above fig; the rest position of bob is O, while its extreme position on either side are A and B.

One oscillation is the motion of bob from O to A, A to B and then back from B to O, (or it is from A to B and back from B to A).

Effective length of a pendulum is shown by T in above figure.

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116. Define least count of a vernier callipers. How do you determine it ?

Ans :

Least count "of a vernier callipers is the difference between one main scale division (M.S.D) and one vernier scale division (V.S.D)".

To determine Least Count of a vernier callipers :

Let n divisions on vernier be of length equal to that of $(n-1)$divisions on main scale and the value of 1 main scale division be$x$.

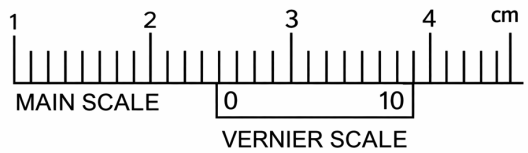
Then Value of n division on vernier $= (n-1)x$

Value of 1 division on vernier $= \dfrac{(n-1)\,x}{n}$

Hence $\text{L.C.} = x - \dfrac{(n-1)\,x}{n} = \dfrac{x}{n}$

i.e., $\text{L.C.} = \dfrac{\text{Value of one main scale division } (x)}{\text{Total number of divisions on vernier } (n)}$ (1.1)

Thus least count of vernier is obtained by dividing the value of one division of main scale by the total number of divisions on vernier scale.



To find least count

In Fig,

Value of 1 division of main scale $x = 1$ mm.

Total number of divisions on vernier $(n) = 10$

$$L.C. = \frac{x}{n}$$

$$= \frac{1\text{mm}}{10}$$

$$= 0.1\text{mm}$$

$$= 0.01\text{cm}$$

117. How does the time period (T) of a simple pendulum depends on its length (l) ? Draw a graph showing the variation of T^2 with l. How will you use this graph to determine the value of g (acceleration due to gravity)?

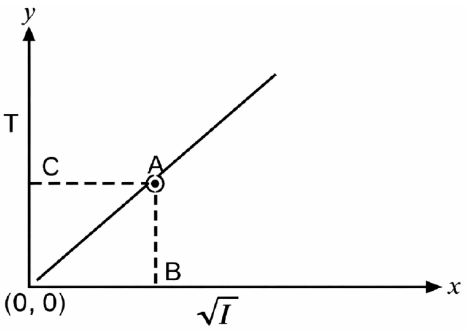
Ans :

Time period (T) of a simple pendulum depends directly to the square root of length $(\sqrt{l})$

i.e. $T \propto \sqrt{l}$

or the square of time period T^2 is proportional to the length l of the pendulum i.e. $T^2 \propto l$ or $\left(\dfrac{l}{T^2}\right)$ is constant

Graph Showing the variation of T with l:



Graph for T against $\sqrt{I}$

If we plot a graph for time period (T) taken on y-axis and square root of length $(\sqrt{l})$ taken on x - axis, it comes out to be a straight line.

To determine the value of 'g' from graph : Take a pt. A on the line. Draw $\perp$ AB and AC on x - axis and

y - axis to find the corresponding values $\sqrt{l}$ and T

Calculate the value of 'g' the acceleration due to gravity from the relation

$$T = 2\pi\frac{\sqrt{l}}{\sqrt{g}}$$

or $$g = \frac{4\pi^2 l}{T^2}$$

118. What do you mean by zero error of a screw gauge? How is it accounted for ?

Ans :

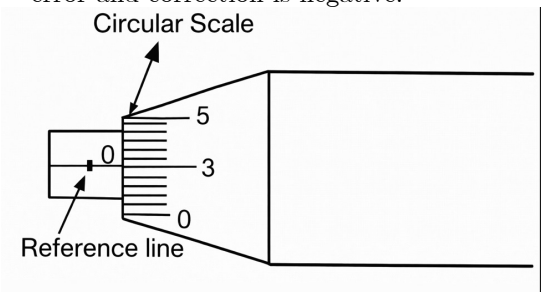
If on bringing the flat end B of the screw in contact with the stud A, the zero mark of the circular scale coincides with the zero mark on base line of the main scale, the instrument is said to be free from zero error. But if it is not so, the instrument is said to have a zero error. For correct measurement, it must be taken into account.

The zero error is of the following two kinds :

(i) Positive zero error and

(ii) Negative zero error.

(i) Positive zero error. If the zero line, marked on the circular scale, is below the reference line of the main scale, then there is positive zero error and correction is negative.



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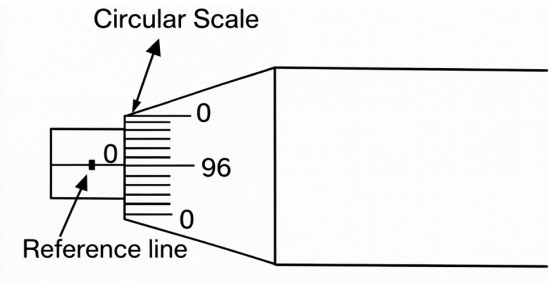
Correct diameter

= observed diameter $\pm$ correction

Correct diameter

= observed diameter -0.003 cm.

(ii) Negative zero error. If the zero line marked on circular scale, is above the reference line of the main scale, then there is a negative error and the correction is positive.
Here 96th division on the circular scale coincides with reference line



Correction

$= +[n -$ coinciding division of $C.S.] \times L.C.$

where n is the total number of circular scale divisions.

Correction $= +[100—96] \times 0.001$cm

$= 0.004$cm

Correct diameter

= observed diameter + 0.004 cm.

NUMERICAL QUESTIONS

119. The wavelength of light is 589 nm. What is its wavelength in $\mathring{A}$?

Ans :

The wavelength of light = 589 nm

We know, $1 \text{ nm} = 10\mathring{A}$

$589\text{nm} = 10 \times 584\mathring{A} = 5890\mathring{A}$

120. A vernier has 10 divisions and they are equal to 9 divisions of main scale in length. If the main scale is calibrated in mm, what is its least count ?

Ans :
Value of 1 M.S.D. = 1 mm
Number of divisions on V.S. = 10

$$\text{L.C. of vernier} = \frac{\text{Value of one M.S.D.}}{\text{Number of divisions on V.S.}}$$

$$= \frac{1}{10} = 0.1 \text{ mm} = 0.01 \text{ cm.}$$

121. A simple pendulum completes 40 oscillations in one minute. Find its (a) frequency, (b) time period.

Ans :
(a) Frequency of simple pendulum
= Number of oscillation completed by it in one second

$$= \frac{40}{60} s^{-1} = 0.67\, s^{-1}$$

(b) Time period of simple pendulum
= Time taken for completing 1 oscillation

NODIA

122. The size of a bacteria is 1μ. Find the number of bacteria in 1 m length.

Ans :

$1\,\mu = 10^{-6}$m

$= \frac{1}{10^6}$m

In $\frac{1}{10^6}$m has 1 bacteria

1m has 1×10^6 $= 10^6$ bacteria

123. The pitch of a screw gauge is 0.5 mm and the head scale is divided in 100 parts. What is the least count of screw gauge ?

Ans :
Pitch of a screw = 0.5 mm
Number of divisions on head scale = 100

$$\text{L.C.} = \frac{\text{Pitch of screw}}{\text{Total number of divisions on head scale}}$$

$$= \frac{0.5 \text{ mm}}{100} = 0.005 \text{ mm}$$

$$= 0.0005 \text{ cm}$$

124. The distance of the nearest star, Proxima Centauri, from the Earth is 4.0×10^{13}km. Express it in light year.

Ans :
Distance of Proxima Centauri from Earth

$= 4.0 \times 10^{13}$km 1 light year

$= 9.46 \times 10^{12}$km

Distance of Proxima Centauri in light year

$$= \frac{4 \times 10^{13}}{9.46 \times 10^{12}}$$

$= 4.228 \cong 4.2$ light year

125. The distance of a galaxy from the earth is 5.6×10^{25}m. Assuming the speed of light to be $3 \times 10^8 \text{ms}^{-1}$, find the time taken by light to travel this distance.

Ans :

The distance travelled by light

$$= 5.6 \times 10^{25}\text{m}$$

The speed of light $= 3 \times 10^{8}\text{ms}^{-1}$

We know, Time taken $= \dfrac{\text{distance tavelled}}{\text{speed}}$

$$\text{Time taken} = \frac{5.6 \times 10^{25}}{3 \times 10^{8}}\text{seconds}$$

$$= 1.866 \times 10^{17}\text{s}$$

$$= 1.87 \times 10^{17}\text{s} \quad (1.87<3.2)$$

126. The time period of a simple pendulum is $2s$. What is its frequency ? What name is given to such a pendulum ?

Ans :

Given, $T = 2s$,

$f = ?$

using, $f = \dfrac{1}{T}$

$$f = \frac{1}{2}s^{-1} = 0.5s^{-1}$$

This is a seconds' pendulum.

127. It takes time 8 min for light to reach from the sun to the earth surface. If speed of light is taken to be$3 \times 10^{8}\text{ms}^{-1}$, find the distance from the sun to the earth in km.

Ans :

Distance in (8×60) Secs.

$$= (3 \times 10^{8} \times 8 \times 60)\,\text{m}$$

$$= \frac{3 \times 48 \times 10^{9}}{1000}\text{km}$$

$$= \frac{144 \times 10^{9}}{100 \times 10} = 1.44 \times 10^{9-1}$$

$$= 1.44 \times 10^{8}\text{km} \qquad \{1.44<3.2\}$$

$10^{0} \times 10^{8}\text{km}$

Order of magnitude $= 10^{8}\text{km}$

128. "The distance of a star from the earth is 8.33 light minutes." What do you mean by this statement ? Express the distance in metre.

Ans :

The distance of stars from earth is generally expressed in light years.

1 light minute $= 1.8 \times 10^{9}\text{m}$

The distance of a star from the earth is 8.33 light minutes.

8.33 light minutes $= 8.33 \times 1.8 \times 10^{9}\text{m}$

$$= 14.99 \times 10^{9}\text{m}$$

$$= 1.5 \times 10^{10}\text{m}$$

129. A microscope is provided with a main scale graduated with 20 divisions in 1 cm and a vernier scale with 50 divisions on it of length same as of 49 divisions of main scale. Find the least count of the microscope.

Ans :

Least count of microscope

$$= \frac{\text{Value of 1 main scale division}}{\text{Number of divisions one the vernier scale}}$$

$$= \frac{\frac{1}{20}\text{cm}}{50} = \frac{1}{100}\,\text{cm} = 0.001\,\text{cm}$$

130. A boy uses a vernier callipers to measure the thickness of his pencil. He measures it to be 1.4 mm. If the zero error of vernier callipers is + 0.02 cm, what is the correct thickness of pencil ?

Ans :

Observed thickness of pencil = 1.4 mm

Zero error $=$ + 0.02 cm

$$= + 0.02 \times 10\text{ mm} = 0.2\text{ mm}$$

Correct thickness of pencil

$$= \text{observed thickness} - \text{zero error}$$

$$= 1.4\text{ mm} - 0.2\text{ mm} = 1.2\text{ mm}$$

131. A vernier callipers has its main scale graduated in mm and 10 divisions on its vernier scale are equal in length to 9 mm.
When the two jaws are in contact, the zero of vernier scale is ahead of zero of main scale and 3rd division of vernier scale coincides with a main scale division. Find : (i) the least count and (ii) the zero error of the vernier callipers.

Ans :

Value of 1 M.S.D. = 1 mm = μ

Number of divisions on V.S. = 10

(i) L.C. of vernier

$$= \frac{\text{Value of one M.S.D.}}{\text{Number of division of V.S.}}$$

$$= \frac{1}{10} = 0.1\,\text{mm}$$

$$= 0.01\,\text{cm}$$

(ii) Zero error of vernier callipers

Now 3rd division of V.S. coincides with main scale division (a head of zero of M.S.)
Zero error is +ve and is + 3 × L.C.

$$= +3 \times 0.01\text{ cm} = +0.03\text{ cm}$$

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132. The thimble of a screw gauge has 50 divisions. The spindle advances 1 mm when the screw is turned through two revolutions.
(i) What is the pitch of screw gauge ?
(ii) What is the least count of the screw gauge ?

Ans :
Pitch of screw gauge is the distance moved by spindle in one revolution $= \frac{1}{2} = 0.5$ mm
(i) pitch $= 0.5$ mm
(ii) Number of divisions on thimble $= (50)$

$$\text{L.C. of screw} = \frac{\text{pitch}}{50}$$
$$= \frac{\frac{1}{2}}{50}$$
$$= \frac{1}{2 \times 50}$$
$$= \frac{1}{100}$$
$$= 0.01 \text{ mm}$$

133. A screw has a pitch equal to 0.5 mm. What should be the number of divisions on its head so as to read correct upto 0.001 mm with its help ?

Ans :
Given,
Pitch of screw
$$= 0.5 \text{ mm}$$
$$\text{L.C.} = 0.001 \text{ mm}$$
$$\text{L.C.} = \frac{\text{pitch}}{\text{number of divisions on head } (n)}$$
Number of divisions
$$(n) = \frac{\text{pitch}}{\text{L.C.}}$$
$$= \frac{0.5 \text{ mm}}{0.001 \text{ mm}}$$
$$= \frac{\frac{5}{10}}{\frac{1}{1000}}$$
$$= \frac{5}{10} \times \frac{1000}{1}$$
$$= 500$$

134. Find the length of a seconds pendulum at a place where $g = 10 \text{ ms}^{-2}$ [Take $\pi = 3.14$].

Ans :
Time period of seconds pendulum at a place is 2
$$= 2\pi\sqrt{\frac{l}{g}} \text{ or } \pi\sqrt{\frac{l}{g}} = 1$$
But $g = 10 \text{ms}^{-2}$
$\pi = 3.14$
$$\pi^2 \frac{l}{g} = 1$$
$$l = \frac{g}{\pi^2}$$
$$= \frac{10}{3.14 \times 3.14}$$
$$= 1.0142 \text{ m}$$
length of pendulum $= 1.0142$ m

135. A pendulum completes 2 oscillations in 5 s.
(a) What is its time period ?
(b) If $g = 9.8 \text{ ms}^{-2}$, find its lengths.

Ans :
Given,
A pendulum completes 2 oscillations in $= 5s$
Time taken to complete 1 oscillation $= \frac{5}{2} = 2.5s$
Time period of pendulum $= 2.5$ seconds
Now $T = 2\pi\sqrt{\frac{l}{g}}$
$$\frac{5}{2} = 2 \times 3.14\sqrt{\frac{l}{9.8}}$$
$$\frac{5}{2} \times \frac{5}{2} = 2 \times 2 \times 3.14 \times 3.14 \times \frac{l}{9.8}$$
Length of pendulum
$$l = \frac{25}{4} \times \frac{9.8}{4 \times 3.14 \times 3.14}$$
$$l = 1.55 \text{ m}$$

136. The time periods of two simple pendulums at a place are in ratio 2 : 1. What will be the ratio of their lengths ?

Ans :
Let l_1 and l_2 be the lengths of two simple pendulums whose time periods are $2T$ and T seconds respectively.
$$2T = 2\pi\sqrt{\frac{l_1}{g}}$$
and $$T = 2\pi\sqrt{\frac{l_2}{g}}$$
$$\frac{2T}{T} = \frac{2\pi\sqrt{\frac{l_1}{g}}}{2\pi\sqrt{\frac{l_2}{g}}}$$
or $$\frac{2}{1} = \sqrt{\frac{l_1}{g} \times \frac{g}{l_2}}$$
or $$\frac{2}{1} = \sqrt{\frac{l_1}{l_2}}$$
Squaring both sides : $\frac{4}{1} = \frac{l_1}{l_2}$
$$l_1 : l_2 = 4 : 1$$

NODIA

137. Compare the time periods of two pendulums of lengths 1 m and 9 m.

Ans :

Time period of a pendulum is given by

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Time period of 1st pendulum :

$$T_1 = 2\pi\sqrt{\frac{l}{g}}$$

Time period of 2nd pendulum

and $$T_2 = 2\pi\sqrt{\frac{9}{g}}$$

$$\frac{T_1}{T_2} = \frac{2\pi\sqrt{\frac{l}{g}}}{2\pi\sqrt{\frac{9}{g}}}$$

$$= \sqrt{\frac{1}{g} \times \frac{g}{9}}$$

$$= \sqrt{\frac{1}{9}}$$

$$= \frac{1}{3}$$

$$\frac{T_1}{T_2} = \frac{1}{3}$$

or $$T_1 : T_2 = 1:3$$

138. The wavelength of light of a particular colour is $5800\mathring{A}$. Express it in (a) nanometre and (b) metre.

Ans :

$$1\mathring{A} = 10^{-10}\text{m}$$

$$5800\mathring{A} = 5800 \times 10^{-10}\text{m}$$

(a) Now $$10^{-9} = 1\text{nm}$$

$$(5800 \times 10^{-10}\text{m}) = \frac{58 \times 10^{-10+2}}{10^{-9}}\text{nm}$$

$$= 58 \times 10^{-8+9}$$

$$= 58 \times 10\text{nm}$$

$$= 580\text{nm}$$

(b) $$1\text{nm} = 10^{-9}$$

$$= \frac{1}{10^9}\text{m}$$

$$580\text{nm} = \frac{1}{10^9} \times 580\text{m}$$

$$= \frac{580}{100} \times 10^{-7}\text{m}$$

$$= 5.8 \times 10^{-7}\text{m}$$

139. How are the following derived units related to the fundamental units ?

(a) newton (b) watt

(c) joule (d) pascal.

Ans :

(a) $$1 \text{ newton} = 1\text{kg} \times 1\,\text{ms}^{-2}$$

$$\text{newton} = \text{kg ms}^{-2}$$

(b) $$1 \text{ watt} = \frac{1 \text{ joule}}{1\text{s}}$$

$$= \frac{1 \text{ newton} \times 1\text{m}}{1\text{s}}$$

$$= \frac{\text{kg ms}^{-2} \times 1\text{m}}{1\text{s}}$$

$$\text{watt} = \text{kg m}^2\text{s}^{-3}$$

(c) $$1 \text{ joule} = 1\text{newton} \times 1\text{metre}$$

$$= 1\text{kg} \times 1\text{ms}^{-2} \times 1\text{m}$$

$$\text{joule} = \text{kg m}^2\text{s}^{-2}$$

(d) $$1\text{pascal} = \frac{1\text{newton}}{1\text{m}^2}$$

$$= \frac{1\text{kg} \times 1\text{ms}^{-2}}{1\text{m}^2}$$

$$\text{pascal} = \text{kg m}^{-1}\text{s}^{-2}$$

NODIA

140. The main scale of a vernier callipers is calibrated in mm and 19 divisions of main scale are equal in length to 20 divisions of vernier scale. In measuring the diameter of a cylinder by this instrument, the main scale reads 35 divisions and 4th division of vernier scale coincides with a main scale division. Find : (i) least count and (ii) radius of cylinder.

Ans :

Value of 1 M.S.D. =1 mm = x

Number of divisions on vernier scale $n = 20$

(i) Least count of vernier

$$= \frac{x}{n} = \frac{1\,\text{mm}}{20}$$

$$= 0.05 \text{ mm}$$

$$= 0.005 \text{ cm}$$

(ii) Diameter of cylinder = main scale reading + V.S.D. coinciding × L.C.

$$= 35 + 4 \times 0.05 \text{ mm}$$

$$= (35 + 0.20) \text{ mm}$$

$$= 35.2 \text{ mm}$$

$$\text{Diameter} = \frac{35.2}{10}$$

$$= 3.52 \text{ cm}$$

$$\text{Radius of cylinder} = \frac{3.52}{2}$$

$$= 1.76 \text{ cm}$$

141. In a vernier callipers, there are 10 divisions on the vernier scale and 1 cm on the main scale is divided in 10 parts. While measuring a length, the zero of the vernier lies just ahead of 1.8 cm mark and 4th division of vernier coincides with a main scale division.
(a) Find the length.
(b) If zero error of vernier callipers is – 0.02 cm, what is the correct length ?

Ans :

$$\text{Value of one M.S.D.} = x = 1\,\text{mm}$$

$$\text{Number of divisions on V.S.} = n = 10$$

$$\text{L.C. of vernier} = \frac{x}{n} = \frac{1}{10} = 0.1\ \text{mm} = 0.01\ \text{cm}$$

Now, correct length = Main scale division + L.C. × (V.S.D. coinciding with M.S.) − error

$$= 1.8\ \text{cm} + 0.01\ (4)\ \text{cm} - (-0.02)\ \text{cm}$$

$$= 1.8 + 0.04 + 0.02$$

$$= 1.84\ \text{cm} + 0.02\ \text{cm} = 1.86\ \text{cm}$$

(a) Length of rod = 1.84 cm
(b) Correct length = 1.86 cm

142. The pitch of a screw gauge is 1 mm and the circular scale has 100 divisions. In measurement of the diameter of a wire, the main scale reads 2 mm and 45th mark on circular scale coincides with the base line. Find
(i) the least count, and
(ii) the diameter of the wire.

Ans :
Given, Pitch of the screw gauge = 1 mm
Number of divisions on circular scale n = 100.
(i) L.C. of screw gauge

$$= \frac{\text{Pitch}}{n} = \frac{1}{100} = 0.01\,\text{mm}$$

$$\text{L.C.} = \frac{0.01\,\text{mm}}{10} = 0.001\,\text{cm}$$

(ii) Reading on the main scale = 2 mm
Division on circular scale coinciding with the base line = 45th

$$\text{Correct diameter} = 2\ \text{mm} + 45 \times \text{L.C.}$$

$$= 2\ \text{mm} + 45 \times 0.01\ \text{mm}$$

$$= 2\ \text{mm} + 0.45\ \text{mm}$$

$$= 2.45\ \text{mm}$$

$$= \frac{2.45}{10} = 0.245\ \text{cm}$$

Correct diameter = 0.245 cm

143. When a screw gauge of least count of 0.01 mm is used to measure the diameter of a wire, the reading on the sleeve is found to be 1 mm and the reading on the thimble is found to be 27 divisions.
(i) What is the diameter of the wire in cm?
(ii) If the zero error is + 0.005 cm, what is the correct diameter ?

Ans :
Given,
Least count of instrument = 0.01 mm
Reading on the main scale = 1 mm
Reading on thimble = 27th
(i) Diameter of the wire

$$= 1\ \text{mm} + 27 \times \text{L.C.}$$

$$= 1\ \text{mm} + 27 \times 0.01\ \text{mm}$$

$$= 1 + 0.27 = 1.27\ \text{mm}$$

$$= \frac{1.27}{10}$$

$$= 0.127\ \text{cm}$$

(ii) $\text{Zero error} = +\ 0.005\ \text{cm}$

$$\text{Correct diameter} = 0.127\ \text{cm} - 0.005\ \text{cm}$$

$$= 0.122\ \text{cm}$$

144. A seconds' pendulum is taken to a place where acceleration due to gravity falls to one-fourth. How is the time period of the pendulum affected, if at all ? Give reason. What will be its new time period ?

Ans :
A pendulum which has time period of two seconds is called seconds pendulum.
Seconds pendulum may also be defined as "a pendulum which completes one oscillation in two seconds."
Now for seconds pendulum

$$2\pi\sqrt{\frac{l}{g}} = 2$$

or $$\pi\sqrt{\frac{l}{g}} = 1 \qquad \ldots(i)$$

At a place where acc.due to gravity falls to (g/4)

$$T' = 2\pi\sqrt{\frac{l}{g/4}}$$

$$= 2\pi\sqrt{\frac{4l}{g}}$$

$$= 4\pi\sqrt{\frac{l}{g}}$$

$$= 4 \times 1$$

$$= 4\ \text{seconds from (i)}$$

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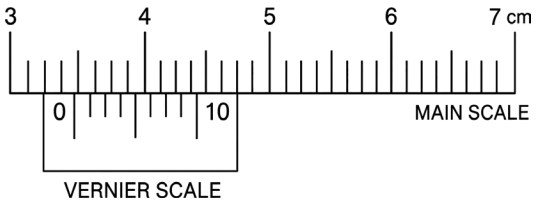
145. While measuring the length of a rod with a vernier callipers, Fig. given below shows the position of its scales. What is the length of the rod ?



Ans :
As zero of the vernier scale lies between 3.3 and 3.4 of main scale.

Reading on the main scale = 3.3 cm

V.S.D. coinciding with the M.S.D. = 6th

Correct length of rod= $3.3 + 6 \times$ L.C.

Value of one M.S.D. =1 mm

$$x = 1 \text{ mm}$$

$$= [3.3 + 6 \times 0.01] \text{ cm}$$

and n = no. of vernier divisions

$$= 10 = 3.36 \text{ cm}$$

$$\text{L.C.} = \frac{1}{10}$$

$$= 0.1\text{mm} = 0.01 \text{ cm}$$

146. A screw gauge has 50 divisions on its circular scale and its screw moves by 1 mm on turning it by two revolutions. When the flat end of the screw is in contact with the stud, the zero of circular scale lies below the base line and 4^{th} division of circular scale is in line with the base line. Find: (i) the pitch, (ii) the least count and (iii) the zero error of the screw guage.

Ans :
Given,
Number of divisions on circular scale = 50
Distance moved in two revolutions = 1 mm
Distance moved in 1 revolution = $\frac{1}{2}$ mm

(i) Pitch $= 0.5$ mm $= 0.05$ cm

(ii) $\text{Least count} = \frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$

$$\text{L.C.} = \frac{0.5}{50} = \frac{5}{5 \times 100}$$

$$= 0.01 \text{ mm}$$

(iii) When the flat end of screw is in contact with stud and zero of circular scale lies 4^{th} divisions $= p$ of circular scale below the base line

Zero error is $= p \times L.C.$

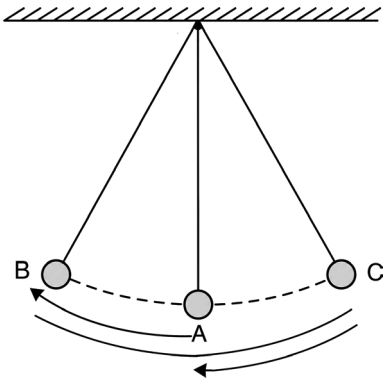
$$= +4 \times 0.01 = +0.04 \text{ mm}$$

147. It takes 0.2 s for a pendulum bob to move from mean position to one end. What is the time period of pendulum ?

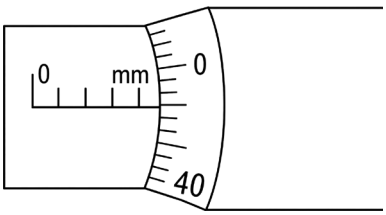
Ans :
Oscillation " is the motion of bob from mean position A to one extreme position B and B to other extreme C and then again to mean position A."
Motion of bob from A to B is $\frac{1}{4}$th of one oscillation.
Time taken to move $\frac{1}{4}$th oscillation = 0.2 s.
Time period T of pendulum is

$$T = 4 \times 0.2$$

$$T = 0.8\, s.$$



148. Figure given below shows the reading obtained while measuring the diameter of a wire with a screw gauge. The screw advances by 1 division on main scale when circular head is rotated once.



Find
(i) pitch of the screw gauge,
(ii) least count of the screw gauge, and
(iii) the diameter of the wire.

Ans :
(i) Pitch of screw gauge = 1 mm
Number of divisions on circular scale = 50
(ii) L.C. of screw gauge

$$= \frac{\text{pitch}}{50}$$

$$= \frac{1}{50} = \frac{2}{100}$$

$$= 0.02 \text{ mm} = 0.002 \text{ cm} = 50$$

NODIA

(iii) Diameter of wire

= Reading on M.S. + Division on circular scale coinciding × L.C.

= 4 mm + 47 × 0.02 mm

= (4 + 0.94) mm

= 4.94 mm

149. How much time does the bob of a seconds pendulum take to move from one extreme of its oscillation to the other extreme ?

Ans :

Time period of a pendulum is the time taken to complete one oscillation. and for second's pendulum time period T = 2 s.

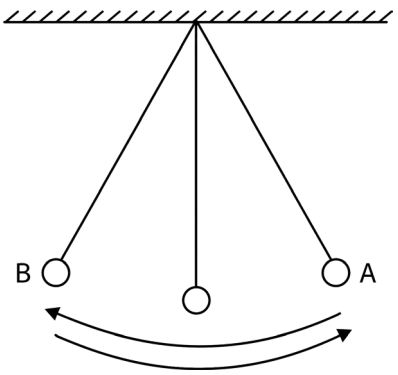
Oscillation is motion of bob from A to B and then back to A

Motion of bob from A to B

i.e. from one extreme position to other extreme position $= \frac{1}{2}$ oscillation

Seconds pendulum takes $= \frac{1}{2} \times 2 = 1$ second to complete $\frac{1}{2}$ oscillation.

1 second



150. Write the derived units of the following :

(a) speed (b) force

(c) work (d) pressure

Ans :

(a) $\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{\text{metre}}{\text{second}}$

Derived unit of speed is ms^{-1}

(b) Force = mass × acceleration

$= \text{mass} \times \text{change in} \frac{\text{velocity}}{\text{time}}$

$= \text{kilogramme} \times \frac{\text{metres}^{-1}}{\text{second}}$

Derived unit of force is $= \text{kg ms}^{-2}$

(c) Work = force × distance

$= \text{mass} \times \frac{\text{change in velocity}}{\text{time}}$

= mass × acceleration × distance

$= \text{kilogramme} \times \frac{\text{metre}}{(\text{second})^2} \times (\text{metre})$

Derived unit of work is $= \text{kg m}^2\text{s}^{-2}$

(d) $\text{Pressure} = \frac{\text{force}}{\text{area}}$

$= \frac{\text{mass} \times \text{acceleration}}{\text{area}}$

$= \text{kilogramme} \times \frac{\text{metre}}{(\text{second})^2} / (\text{metre})^2$

Derived unit of pressure is $= \text{kg m}^{-1}\text{s}^{-2}$

CASE BASED QUESTIONS

151. Meera is experimenting with periodic motion in her school laboratory. She sets up a heavy metallic spherical bob of mass 100 g and suspends it using a fine thread of length 100 cm from a rigid support. She pulls the bob slightly to one side and lets it swing back and forth, recording the time taken. The acceleration due to gravity in the laboratory is 9.8 m s^{-2}. Later, she replaces the 100 g bob with a heavier 200 g bob of the same dimensions and swings it again.

(a) Calculate the time period of the pendulum for her first experimental setup.

(b) Define the term amplitude as applied to the periodic motion of Meera's pendulum.

(c) State the exact effect on the time period when the00 g bob is replaced with the 200 g bob.

Ans :

(a) $T = 2\pi \sqrt{(l / g)}$

$T = 2 \times 3.14 \times \sqrt{(1 \text{ m} / 9.8 \text{ m s}^{-2})}$

T = 1.99 s

(b) The maximum displacement of the pendulum bob from its resting mean position on either side is defined as the amplitude of the oscillation.

(c) The time period will remain completely unaffected because the time period of a simple pendulum is independent of the mass of the bob.

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152. Arjun measures the diameter of a solid cylinder using a Vernier calliper in his physics laboratory. Before placing the cylinder, he brings the jaws together to check for mechanical errors. He observes that the zero mark on the Vernier scale does not perfectly align with the zero mark on the main scale, but instead rests slightly to the left of the main scale zero. The instrument has 10 divisions on the Vernier scale which equal 9 divisions on the main scale, where each main scale division is 1 mm.

(a) Name the specific type of zero error present in Arjun's instrument and state the mathematical sign given to it.

(b) Calculate the least count of the Vernier calliper in millimetres.

(c) State how this specific zero error should be treated mathematically to find the correct true reading.

Ans :

(a) The error is negative zero error, and it is given a minus sign because the Vernier zero is to the left of the main scale zero.

(b) L.C. = Value of one main scale division / Total number of Vernier divisions
L.C. = 1 mm / 10 L.C. = 0.1 mm

(c) To get the correct true reading, the negative zero error with its proper minus sign must be subtracted from the observed mean reading.

153. Sneha is measuring the thickness of a rectangular glass slab using a micrometer screw gauge. The micrometer has exactly 50 divisions marked on its circular scale. Before starting, she observes that the spindle advances linearly by exactly 1 mm when the circular scale is given two complete rotations. While taking her final measurement, she accidentally turns the thimble too far and reverses the direction of rotation suddenly, noticing that the tip of the screw does not start moving in the opposite direction immediately.

(a) Calculate the pitch and the least count of Sneha's micrometer in millimetres.

(b) Name the specific error caused by reversing the screw direction and state one precaution to avoid it.

Ans :

(a) Pitch

= Distance moved / Number of rotations

= 1 mm / 2 = 0.5 mm

L.C. = Pitch / Total circular scale divisions

L.C. = 0.5 mm / 50 = 0.01 mm

(b) 1. This specific mechanical deviation is known as backlash error, caused by wear and tear of the screw threads.

2. To avoid it, the screw should always be rotated in one single direction only while taking the final measurement.

154. Rahul is reading a physics astronomy chart that expresses distances between celestial bodies using macroscopic units. He reads that a particular star is located at a distance of exactly one light year from Earth. He knows that light travels extremely fast and wants to calculate the exact distance using standard SI units. He takes the speed of light in a vacuum to be exactly 3×10^8 m s^{-1} and records the total time for one year as 3.1536×10^7 s.

(a) Calculate the exact value of one light year in metres using Rahul's recorded data.

(b) Define the astronomical unit (AU) and state its precise accepted value in metres.

Ans :

(a) Distance

= Speed of light × Time in one year

= $(3 \times 10^8$ m $s^{-1}) \times (3.1536 \times 10^7$ s)

= 9.46×10^{15} m

(b) 1. The astronomical unit is defined as the mean or average distance between the Sun and the Earth.

2. The accepted value of one astronomical unit is exactly 1.496×10^{11} m.

155. Kabir is assigned a task to classify and write the standard units of various physical quantities in his physics practical notebook. He writes the SI unit of force as newton, the unit of pressure as pascal, and the unit of temperature as kelvin. During his documentation, he also writes the symbol for electric current as 'amp' and records the output of a large power station as '1 KMW'. His teacher reviews the notebook and points out several formatting mistakes according to strict SI conventions.

(a) Identify the one fundamental physical quantity mentioned in Kabir's list.

(b) Deduce the derived unit of force (newton) expressed strictly in terms of fundamental SI units.

(c) State the correct rule for writing the symbol of the unit of electric current.

(d) State why writing 'KMW' is strictly incorrect according to the rules for writing SI units.

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Ans :

(a) Temperature is the only fundamental physical quantity present in Kabir's recorded list.

(b) $$\text{Force} = \text{Mass} \times \text{Acceleration}$$
$$\text{Unit} = \text{kg} \times (\text{m} / \text{s}^2)$$
$$\text{Unit} = \text{kg m s}^{-2}$$

(c) The symbol for a unit named after a scientist must be written as a single upper case letter, which is 'A' for ampere, never 'amp'.

(d) Writing 'KMW' is incorrect because the SI rules state that a unit must not be written with more than one compound prefix attached to it.

156. Ananya is studying both atomic and astronomical physical quantities for her upcoming physics examination. She notes down the mass of a single carbon-12 atom to understand how atomic masses are standardized. Later, she writes down the mass of the Sun to learn how astronomers measure immensely large heavenly bodies. She also reviews the time taken by the Earth to complete one full revolution around the Sun, and memorises the exact definition of a lunar month based on orbital periods.

(a) State the exact definition of one atomic mass unit as studied by Ananya.

(b) State the exact numerical value of one solar mass expressed in kilograms.

(c) Name the specific time unit defined as the period of revolution of the Moon around the Earth.

(d) State the exact number of leap years present in a standard century consisting of one hundred years.

Ans :

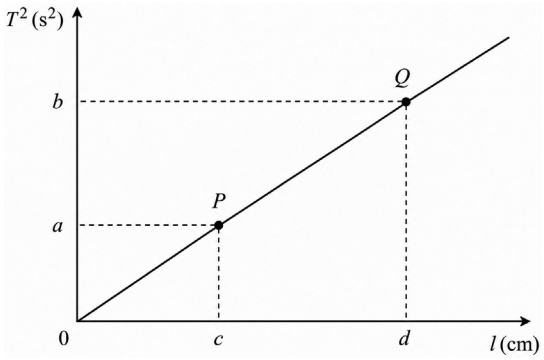
(a) One atomic mass unit is defined as exactly one-twelfth the mass of one single carbon-12 atom at rest.

(b) One solar mass is used to measure large heavenly bodies and is equal to 2×10^{30} kg.

(c) The time taken by the Moon to complete one full revolution around the Earth is known as a lunar month.

(d) Out of the one hundred years that make up a standard century, exactly twenty-four years are leap years.

157. Yash plots a graph using experimental data obtained from a hanging spherical mass oscillating on a string. He marks two points on the resulting straight line to find a specific constant related to the local acceleration due to gravity. He refers to the graph showing the squared time values against the thread length below.



(a) State what the slope of this specific plotted graph represents physically in terms of the constant pi and gravity.

(b) Deduce the exact mathematical formula for the slope of the graph using the designated points P and Q with their respective axis intercepts a, b, c, and d.

(c) State how the time period of the pendulum is affected if the experimental setup is taken to a high mountain.

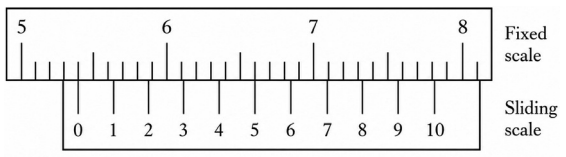
Ans :

(a) The slope of this specific straight-line graph calculated at any given place is equal to the constant value $4\pi^2 / g$.

(b) $$\text{Slope} = \frac{\text{PR}}{\text{QR}}$$
$$\text{Slope} = \frac{\text{ab}}{\text{cd}}$$
$$\text{Slope} = \frac{(\text{a} - \text{b})}{(\text{c} - \text{d})}$$

(c) As acceleration due to gravity decreases at high altitudes on a mountain, the time period of the pendulum will increase.

158. Riya places a solid metal block between the external jaws of a measuring instrument to find its accurate length. She carefully records the position of the sliding scale against the fixed scale. The least count of the instrument is given to her as 0.01 cm. She references the diagram showing the aligned scales below.



Least count = 0.1 cm − 0.09 cm = 0.01 cm

Reading = 5.3 cm + 7 × 0.01 cm = 5.37 cm

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(a) Calculate the exact observed length of the metal block based on the scale alignment shown in the diagram.
(b) Identify the proper technical name of the lower sliding scale shown in the diagram.
(c) State the mathematical formula used to calculate the true length if the instrument has a previously recorded zero error.

Ans :

(a) Observed Length

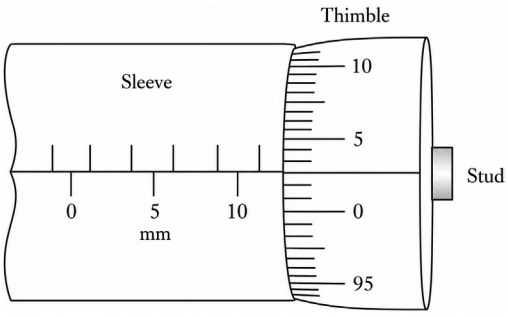
= Main Scale Reading + (Coinciding Division × Least Count)

Observed Length = 5.3 cm + (7 × 0.01 cm)

Observed Length = 5.37 cm

(b) The lower sliding scale with ten equally spaced subdivisions is known as the Vernier scale.
(c) True length is calculated by subtracting the zero error along with its proper positive or negative sign from the observed length reading.

159. Manish rotates the thimble of a micrometre until the anvil and spindle are gently touching each other without any object placed in between them. He carefully notes the position of the circular scale relative to the main scale baseline to check for any built-in mechanical deviation before starting his experiment. The instrument has a least count of 0.001 cm. He references the diagram showing this resting condition below.



(a) Name the specific type of error present in Manish's instrument and state the physical reason why it occurs.
(b) Calculate the precise magnitude of this zero error using the given least count and the alignment shown in the diagram.

Ans :

(a) 1. The measuring instrument possesses a positive zero error.
2. This error occurs because of improper mechanical calibration or mechanical wear, preventing the zero marks from perfectly matching.

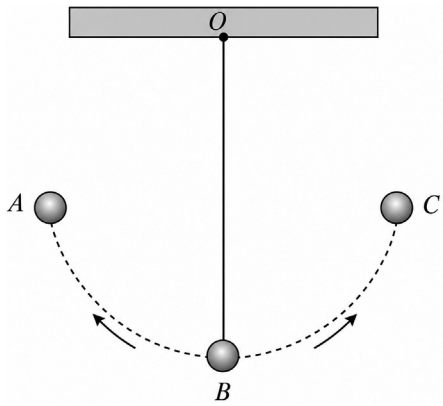
(b) Positive Zero Error

= +(Coinciding Division × Least Count)

Positive Zero Error = +(5 × 0.001 cm)

Positive Zero Error = +0.005 cm

160. Divya suspends a heavy metallic sphere from a rigid stand to study its periodic motion in the laboratory. She pulls the sphere to one side and releases it smoothly, carefully observing its continuous swing along a curved path in the air. She notes the exact points where the sphere momentarily stops before reversing direction. She references the diagram showing the different positions of the sphere below.



(a) Identify the exact label representing the mean position and the labels representing the extreme positions from the diagram.
(b) State the exact sequence of movement between the labelled points that constitutes one single complete oscillation of the sphere.

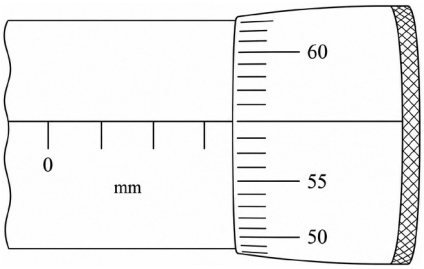
Ans :

(a) 1. The vertically lowest central position B represents the resting mean position of the sphere.
2. The elevated side positions A and C represent the extreme positions of the sphere.

(b) 1. One complete oscillation begins when the sphere moves from the extreme position A to the mean position B, and then to extreme position C.

2. It is completed when it travels from extreme position C back through the mean position B, returning to the starting extreme position A.

161. Varun uses a rotating measuring device to find the precise diameter of a uniform metal wire. He places the wire securely between the flat jaws and gently turns the ratchet until it clicks, ensuring the wire is not crushed. The pitch of his instrument is exactly 1 mm and there are exactly 100 divisions on the circular scale. He references the diagram showing the final scale reading below.



(a) Calculate the least count of the measuring device in centimetres.
(b) Identify the exact main scale reading from the given diagram in centimetres.
(c) Identify the exact coinciding circular scale division from the diagram.
(d) Calculate the final observed diameter of the wire in centimetres assuming there is no zero error.

Ans :

(a) L.C. = Pitch/Total circular scale divisions

L.C. = 1 mm / 100

L.C. = 0.001 cm

(b) The main scale reading is 3 mm, which is exactly 0.3 cm.
(c) The coinciding circular scale division perfectly aligning with the baseline is 56.
(d) Diameter

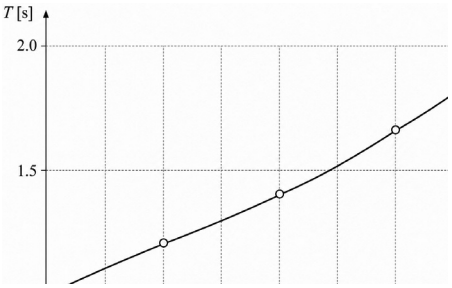
= Main Scale Reading

+ (Coinciding Division × Least Count)

Diameter = 0.3 cm + (56 × 0.001 cm)

Diameter = 0.356 cm

162. Kavita performs an extensive experiment recording the total time taken for twenty complete oscillations of a pendulum at varying string lengths. She carefully divides her recorded times by twenty to find the accurate time for a single oscillation and plots her final results on grid paper. She references the graph showing the resulting plotted curve below.



(a) State the exact physical name of the time interval represented by the uppercase letter T on the vertical axis.
(b) Read the exact value of T from the graph when the value of l is equal to one hundred centimetres.
(c) State the mathematical proportionality relationship between the variables T and l based on the curved shape of this graph.
(d) State how the shape of the graph would definitively change if T was plotted against the square root of l instead.

Ans :

(a) The variable T represents the time period of the simple pendulum.
(b) When the length l is one hundred centimetres, the time period T on the graph is exactly 2.0 s.
(c) The time period T is directly proportional to the square root of the effective length l of the pendulum.
(d) If the time period T was plotted against the square root of l, the resulting graph would be a perfectly straight line inclined to the axes.

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CHAPTER 2

Motion in One Dimension

SUMMARY

1. REST AND MOTION

A body is said to be at rest if its position with respect to its surrounding does not change.

A body is said to be in motion if its position changes with respect to its surroundings.

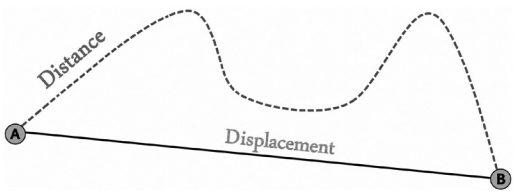
2. ONE DIMENSIONAL MOTION

When a body moves along a straight line path, its motion is said to be one dimensional motion. It is also called motion in a straight line or rectilinear motion.

3. DISTANCE AND DISPLACEMENT

The total length of the path travelled by a body is called the distance travelled by that body. This path may or may not be straight. It is a scalar quantity and is represented by S. Its SI unit is metre (m).

The shortest distance from the initial to the final position of the body is called magnitude of displacement. Its direction is from the initial to the final position.



It is a vector quantity and is represented by S. Its SI unit is also metre (m).

3.1 Distinction between distance and displacement

The difference between the distance and displacement are as follows :

Distance	Displacement
It is the length of path travelled by an object in a certain time.	It is the shortest distance between the initial and final positions.
It is a scalar.	It is a vector.
It depends on the path followed by the object.	It is independent of the path of the object.
It can be more than or equal to the magnitude of displacement.	Its magnitude can be less than or equal to the distance.

4. SPEED

Speed is defined as 'the distance travelled by an object per unit time' or 'the rate of change of distance with time'.

$$\text{Speed(v)} = \frac{\text{Distance (S)}}{\text{time (t)}}$$

The SI unit of speed is metre per second and is written as m s^{-1}. It is a scalar quantity.

4.1 Uniform speed

Uniform speed is possessed by an object when it travels equal distances in equal intervals of time, no matter how small these time intervals may be.

4.2 Non-uniform or variable speed

Non-uniform speed is possessed by an object when it travels unequal distances in equal intervals of time, no matter how small these time intervals may be.

4.3 Instantaneous speed

When the speed of a body changes continuously with time, its speed at a particular instant is known as instantaneous speed. The speedometer of a vehicle measures the instantaneous speed.

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4.4 Average speed

The average speed of a body is the total distance travelled by the body divided by the total time taken to cover this distance.

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

5. VELOCITY

The velocity of a body is defined as 'the distance travelled by an object per unit time in a given direction'.

$$\text{Velocity} = \frac{\text{Distance travelled in a given direction}}{\text{Time taken}}$$

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time taken}}$$

1. The SI unit of velocity is metre per second and is written as m s^{-1}
2. Velocity is a vector quantity.

5.1 Uniform velocity

Uniform velocity is possessed by an object when it travels in a specified direction in a straight line and covers equal distances in equal intervals of time, no matter how small these time intervals may be.

5.2 Non-uniform or variable velocity

Non-uniform velocity is possessed by an object when it travels in a specified direction in a straight line and covers unequal distances in equal intervals of time.

It is also possessed when the object travels equal distances in equal intervals of time, but the direction does not remain the same.

5.3 Instantaneous velocity

When the velocity of a body changes continuously with time, its velocity at a particular instant is known as instantaneous velocity.

5.4 Average velocity

The average velocity of a body is the displacement of the body divided by the total time taken to cover the entire journey.

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Total time taken}}$$

Speed	Velocity
The distance travelled by a moving object per unit time is speed	The distance travelled by a moving object per unit time in a particular direction is velocity.
It is a scalar.	It is a vector.
It is always positive.	It may be positive or negative depending on the direction of motion.
If the body is moving in a circle, then after one round, the average speed is not zero.	If the body is moving in a circle then after one round, the average speed is not zero.

6. ACCELERATION

Acceleration of a body is defined as 'the rate of change of its velocity with time'.

$$\text{Acceleration} = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{Time taken for change}}$$

$$a = \frac{v - u}{t}$$

1. The SI unit of acceleration is metre per second square and is written as m s^{-1}
2. Acceleration is a vector quantity.

6.1 Uniform Acceleration

A body is said to possess uniform acceleration if it travels in a straight line and its velocity increases by equal amounts in equal intervals of time.

6.2 Non-uniform or variable acceleration

A body is said to possess non-uniform acceleration if its velocity increases by unequal amounts in equal intervals of time.

Acceleration due to gravity

1. When a body falls freely under the influence of gravity, the acceleration produced in the body is acceleration due to gravity.
2. It is denoted by the letter 'g'.

Retardation

When the velocity of a body increases with time, it is called acceleration. However, if the velocity decreases, then it is called retardation, deceleration or negative acceleration.

7. GRAPHICAL REPRESENTATION OF LINEAR MOTION

7.1 Displacement-time graph

1. This graph has displacement along the y-axis and time along the x - axis.
2. The slope of the displacement-time graph gives the velocity of the body.
3. If the slope is positive, then the body is moving away from the point where it started. However, if the slope is negative, then the body is moving back towards the starting point.

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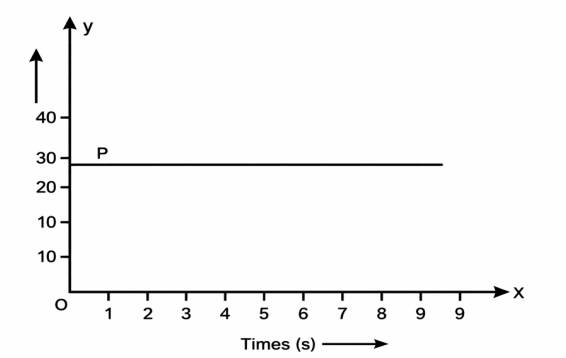
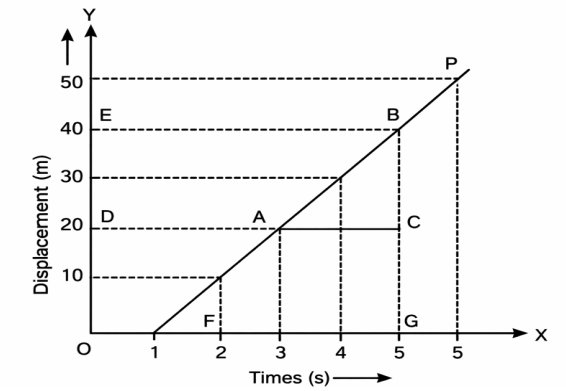
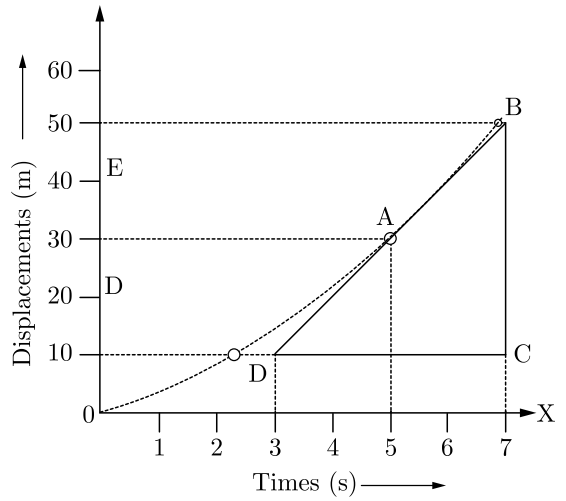
Case I: For a stationary body.



Case II: For a body moving with uniform velocity.



Case III: For a body moving with variable velocity.

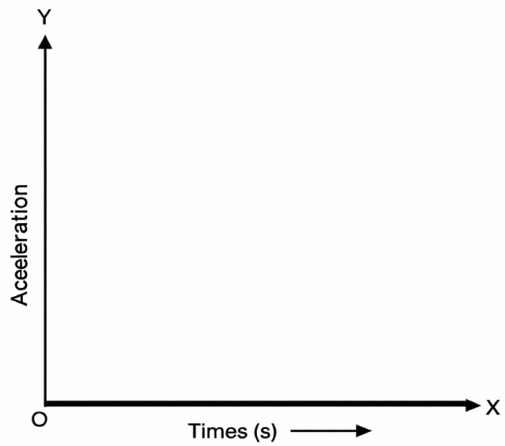


7.2 Velocity-time graph

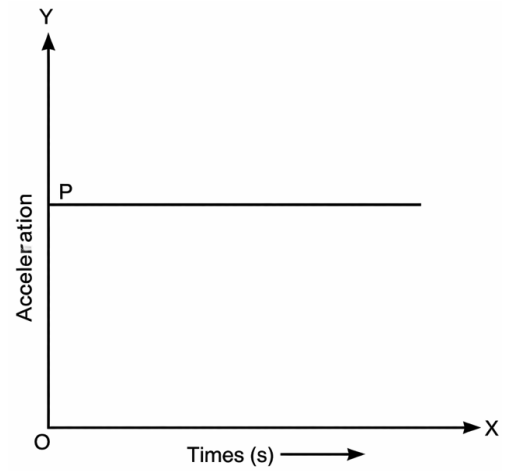
1. This graph has velocity along the y-axis and time along the x-axis.
2. The slope of the velocity-time graph gives the acceleration of the body. Also, displacement of the body can be found from this graph.
   (a) Finding displacement : Displacement is the product of velocity and time. Hence, the area enclosed by the velocity-time graph will give the displacement of the body.
   (b) Finding acceleration : Acceleration is the ratio of velocity to time. Thus, the slope of the graph will give the acceleration of the body.

7.3 Acceleration — time graph

This graph has acceleration along the y - axis and time along the x - axis. The change in speed of the body can be found from this graph by finding the area enclosed under the graph.
The following cases are possible:
Case I: For a stationary body or a body moving with uniform acceleration.
The acceleration - time graph is a straigth line coinciding with the time axis.



Case II: For a body moving with uniformly increasing velocity.
The acceleration - time graph will be a straigth line parallel to the time axis.



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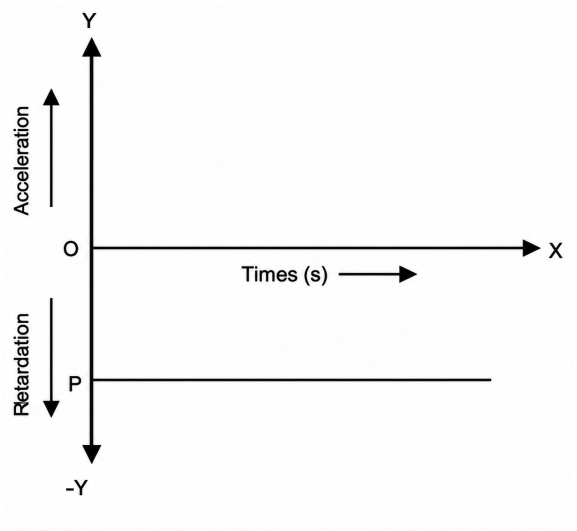
Case III: For a body moving with uniformly decreasing velocity.
The acceleration - time graph is a straight line parallel to the time axis and on the negative acceleration axis.



8. MOTION UNDER GRAVITY

When a body falls freely on the Earth under the influence of gravity, it is said to be moving with constant acceleration. Its value is 9.8 m/s^2.

Similarly, when a body is moving upwards against gravity, it is said to be moving with constant retardation. Its value is also 9.8 m/s^2.

9. EQUATIONS OF MOTION

The equations of motion are considered for a body moving with uniform acceleration. The three equations of motion can be derived using the velocity-time graph:

First equation: $v = u + at$

Second equation: $s = ut + \frac{1}{2}at^2$

Third equation: $v^2 = u^2 + 2as$

OBJECTIVE QUESTIONS

1. Which of the following parameters is strictly required to completely express a vector quantity but is entirely unnecessary for a scalar quantity?
(A) Numerical value of the measured quantity
(B) Unit in which the quantity is being measured
(C) Direction of the physical quantity
(D) Pure numerical magnitude

Ans : (C)

A scalar quantity requires only a numerical value and a unit to be completely expressed. A vector quantity inherently demands a numerical value, a unit, and a specific direction. Without a direction, the meaning of any vector quantity remains incomplete.

2. A car driver applies brakes, and the car's velocity is recorded until it stops.

Time (s)	Velocity (m/s)
0	25
1	20
2	15
3	10
4	5
5	0

What is the magnitude of the uniform retardation of the car?
(A) -5 m/s^2
(B) 5 m/s^2
(C) 25 m/s^2
(D) -25 m/s^2

Ans : (B)

Retardation is the rate of decrease in velocity. Acceleration is $a = (v - u) / t = (0 - 25) / 5 = -5$ m/s^2. Retardation is defined as the positive magnitude of this negative acceleration. Therefore, the retardation is 5 m/s^2. The term itself implies a decrease in speed.

3. **Assertion (A) :** The state of rest and the state of motion of a body are considered to be relative terms.
Reason (R) : A body can change its position with respect to one immediate surrounding reference point while remaining stationary relative to another.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Motion is mathematically described without reference to its cause by comparing position against a reference point. A passenger in a moving train is at rest relative to the train but in motion relative to the platform, making these states

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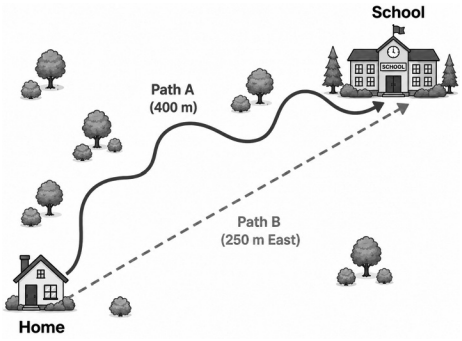
relative.

4. A student walks from their home to school following the winding path shown. The diagram illustrates two physical quantities related to their journey. Which of the following is a vector quantity?



(A) The length of Path A
(B) The length of Path B with its direction
(C) The time taken for the journey
(D) The average speed along Path A

Ans : (B)

A vector quantity requires both magnitude and direction for its complete description. Path B is defined by its magnitude (250 m) and a specific direction (East), representing displacement. Path A's length, time, and speed are scalar quantities as they are fully described by their magnitude alone, without a specific direction being necessary.

5. ector quantities follow specific laws for their mathematical operations. Which of the following mathematical frameworks is strictly utilized for the addition and subtraction of vector quantities?
(A) Basic arithmetic laws
(B) Specific vector laws
(C) Simple algebraic laws
(D) Standard statistical laws

Ans : (B)

Vector quantities require specific vector laws for their addition, subtraction, multiplication, and division. They cannot be manipulated using ordinary algebraic laws because their operations must account for both the magnitude and the specific spatial direction of the physical quantities involved.

6. When a body moves along a straight-line path, its motion is classified as one-dimensional. Which of the following examples best represents this type of motion?
(A) A bird flying freely in the open sky
(B) A train moving on a straight railway track
(C) The earth revolving in an orbit around the sun
(D) A boy walking along a curved circular path

Ans : (B)

One-dimensional motion, also termed rectilinear motion, involves movement strictly along a straight line with no lateral or sideways displacement. A train moving on a straight track perfectly demonstrates this, whereas flying birds or revolving planets represent two or three-dimensional motions.

7. The table below provides the velocity of a body at different instants, showing it is undergoing uniform acceleration.

Time (s)	Velocity (m/s)
0	10
2	16
4	22
6	28

What is the acceleration of the body?
(A) 10 m/s^2
(B) 6 m/s^2
(C) 3 m/s^2
(D) 2 m/s^2

Ans : (C)

Acceleration is the slope of the velocity-time data, calculated as the change in velocity divided by the change in time. From t=0 to t=2 s, a = (16 - 10) m/s / (2 - 0) s = 6 m/s / 2 s = 3 m/s^2. This is consistent for all intervals, confirming uniform acceleration.

8. A boy travels 4 km towards the East and then turns left to travel 3 km towards the North. What is the magnitude of his displacement from the initial starting point?
(A) 7 km
(B) 1 km
(C) 5 km
(D) 12 km

Ans : (C)

The total distance traveled by the boy is the sum of both paths, totaling seven kilometers. However, the displacement is the shortest straight-line length between the initial and final positions, calculated using the Pythagorean theorem as exactly five kilometers.

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9. The diagram shows a passenger 'P' sitting inside a train moving with a constant velocity to the right, as observed by a person 'O' standing on the stationary platform. Which statement correctly describes the state of motion?

(A) P is at rest with respect to O, but in motion with respect to the train.
(B) P is in motion with respect to O, but at rest with respect to the train.
(C) P is at rest with respect to both O and the train.
(D) P is in motion with respect to both O and the train.

Ans : (B)

Motion is a relative concept. Since passenger P is not changing their position relative to their immediate surroundings within the train, P is at rest with respect to the train. However, as the train moves, P's position continuously changes with respect to the stationary observer O on the platform, so P is in motion with respect to O.

10. Match the physical quantities in List-I with their accurate classification characteristics in List-II.
List-I (Quantity)
P. Mass
Q. Weight
R. Distance
S. Velocity
List-II (Characteristic)
I. Vector quantity indicating the rate of displacement
II. Scalar quantity possessing exclusively numerical magnitude
III. Vector quantity representing a downward gravitational pull
IV. Scalar quantity representing the actual path covered
(A) P-II, Q-III, R-IV, S-I
(B) P-III, Q-I, R-II, S-IV
(C) P-IV, Q-II, R-I, S-III
(D) P-I, Q-IV, R-III, S-II

Ans : (A)

Mass is a scalar quantity possessing only magnitude. Weight is a vector quantity representing gravitational pull. Distance is a scalar representing the actual path covered. Velocity is a vector quantity indicating the rate of change of displacement with time.

11. Under which of the following specified conditions will the displacement of a moving object be precisely equal to zero while the total distance traveled remains non-zero?
(A) When the object moves along a straight-line path in one fixed direction
(B) When the object remains continuously at rest at its initial reference point
(C) When the object returns exactly to its initial starting point after traveling
(D) When the object moves with a strictly uniform velocity in a single direction

Ans : (C)

Displacement represents the shortest distance between the initial and final positions. If a moving body returns exactly to its starting point after completing a journey, the final and initial positions coincide, making displacement zero despite a non-zero distance traveled.

12. Consider the following statements regarding distance and displacement:
I. Distance is a measurement of the actual path length covered by a moving body.
II. Displacement can be zero even if the distance traveled is not zero.
III. The magnitude of displacement can sometimes be greater than the distance.
IV. Distance is a scalar quantity while displacement is a vector quantity.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III and IV
(C) I, III and IV
(D) I, II, III and IV

Ans : (A)

Distance is the actual scalar path length covered. Displacement is the shortest vector distance between initial and final positions. The magnitude of displacement is always less than or equal to the total distance, meaning it can never logically exceed it.

13. **Assertion (A) :** The magnitude of displacement of a moving body can never be strictly greater than the distance traveled by that same body.
Reason (R) : Displacement is the shortest length measured in a specified direction from the initial position to the final position.

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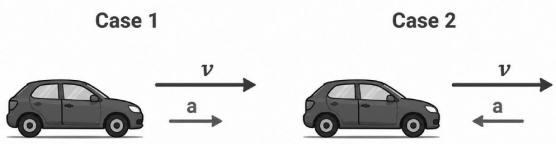
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Distance measures the complete path length traversed, whereas displacement measures the shortest possible straight-line distance between the start and end points. Therefore, displacement magnitude is mathematically restricted and can never exceed the total distance covered during the entire journey.

14. The diagram shows two cases of a car's motion. In Case 1, the velocity (v) and acceleration (a) are in the same direction. In Case 2, they are in opposite directions. How is the car's speed affected in each case?



(A) Case 1: Speed increases; Case 2: Speed is constant.
(B) Case 1: Speed decreases; Case 2: Speed increases.
(C) Case 1: Speed is constant; Case 2: Speed decreases.
(D) Case 1: Speed increases; Case 2: Speed decreases.

Ans : (D)

Explanation: When acceleration is in the same direction as velocity (Case 1), it causes the magnitude of the velocity (speed) to increase; this is positive acceleration. When acceleration is in the opposite direction to velocity (Case 2), it causes the speed to decrease; this is known as retardation or negative acceleration.

15. A body is defined as having uniform motion under a specific set of physical conditions. Which of the following best describes uniform motion in one dimension?
(A) The body travels equal distances in equal intervals of time, no matter how small the time intervals may be.
(B) The body travels unequal distances in equal intervals of time along a straight-line path.
(C) The body covers a very large distance in an exceptionally short interval of time.
(D) The body maintains a constant distance from a fixed stationary reference point.

Ans : (A)

A body is said to have uniform motion when it successfully travels equal distances in equal intervals of time. This holds true consistently regardless of how incredibly small these measured time intervals might be during the entire observation period.

16. The speed of a moving body is formally defined as the rate of change of distance travelled by it in a unit time. What is the SI unit of speed?
(A) centimetre per second
(B) kilometre per hour
(C) metre per second
(D) metre per square second

Ans : (C)

Speed is a scalar quantity representing the distance covered per unit time. Because the standard SI unit of distance is the metre and the SI unit of time is the second, the fundamental SI unit of speed is metre per second.

17. In practical life, most automobiles move with non-uniform or variable speed. Which device in an automobile continuously reads its instantaneous speed?
(A) Odometer
(B) Speedometer
(C) Accelerometer
(D) Tachometer

Ans : (B)

For a body undergoing non-uniform motion, its speed constantly changes at every moment. The speedometer of a moving automobile is specifically designed to measure and display the exact instantaneous speed of the vehicle at any particular given instant of time.

18. Identify the correct statements concerning speed and velocity:
I. Speed is a scalar quantity while velocity is a vector quantity.
II. Both speed and velocity can perfectly indicate the direction of a moving body.
III. The speed of a moving body is always positive, but its velocity can be negative.
IV. Average velocity can be zero even if the average speed is not zero.
Which of the above statements are correct?
(A) I, II and III

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(B) I, III and IV
(C) II, III and IV
(D) I, II, III and IV

Ans : (B)

Speed tells us how fast a body moves but provides no directional information. Velocity includes both speed and direction, allowing it to be negative if moving oppositely. Average velocity becomes zero when total displacement is zero, unlike average speed.

19. Moving bodies generally do not maintain a constant velocity; they often undergo changes in speed or direction. What is the rate of change of velocity of a moving body with time formally called?
(A) Retardation
(B) Acceleration
(C) Average speed
(D) Instantaneous velocity

Ans : (B)

Acceleration is formally defined as the precise rate of change of velocity of a moving body with respect to time. It is a vector quantity that completely describes how quickly a body increases its velocity during a specific time interval.

20. Analyze the following statements about a velocity-time graph carefully:
I. A straight line inclined to the time axis indicates uniform acceleration.
II. A curve indicates that the body is moving with variable acceleration.
III. A line sloping downwards with a negative gradient always implies constant velocity.
IV. The velocity-time graph can never be a straight line parallel to the velocity axis.
Which of these statements are fundamentally correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I, III and IV

Ans : (B)

An inclined straight line represents uniform acceleration, and a curve signifies variable acceleration. A graph parallel to the velocity axis implies an impossible infinite acceleration. A downward sloping line specifically represents uniform deceleration, completely contradicting the concept of constant velocity.

21. A car travels a distance of 100 km in 2 hours along a strictly straight path in the North direction. What is the velocity of the car?
(A) 50 km per hour without any specific direction
(B) 100 km per hour towards the North
(C) 50 km per hour towards the North
(D) 200 km per hour towards the North

Ans : (C)

Velocity is calculated as the total displacement divided by the total time taken. Since the car travels one hundred kilometers in two hours due North, the resulting velocity is exactly fifty kilometers per hour directed specifically towards the North.

22. An athlete runs on a circular track of radius 50 m. The time taken to complete one full revolution is recorded.

Parameter	**Value**
Radius (r)	50 m
Time for one lap (T)	50 s
π (pi)	3.14

After completing exactly one revolution, what are the athlete's average speed and average velocity?
(A) Average speed = 6.28 m/s, Average velocity = 6.28 m/s
(B) Average speed = 0 m/s, Average velocity = 0 m/s
(C) Average speed = 6.28 m/s, Average velocity = 0 m/s
(D) Average speed = 0 m/s, Average velocity = 6.28 m/s

Ans : (C)

After one revolution, the athlete returns to the starting point, making the net displacement zero. Thus, the average velocity (displacement/time) is 0 m/s. The distance covered is the circumference, $2\pi r = 2 \times 3.14 \times 50 = 314$ m. The average speed (distance/time) is 314 m / 50 s = 6.28 m/s.

23. When a driver applies the brakes to a speeding car, the vehicle gradually slows down before coming to a complete stop. Which term correctly describes this specific type of motion?
(A) Positive acceleration
(B) Uniform velocity
(C) Negative acceleration
(D) Constant speed

Ans : (C)

When the velocity of a moving body decreases as time progresses, the rate of change of velocity becomes negative. This specific condition is universally referred to as negative acceleration,

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or more commonly known as retardation or deceleration in classical physics.

24. Acceleration is determined by dividing the change in velocity by the time interval. Based on this relationship, what is the proper SI unit of acceleration?
(A) metre per second
(B) kilometre per hour
(C) metre per square second
(D) centimetre per second

Ans : (C)

Acceleration calculates the change in velocity over time. Since the standard SI unit of velocity is metre per second and time is measured in seconds, dividing velocity by time yields metre per square second as the correct fundamental SI unit.

25. The table shows the displacement of a body moving with uniform velocity at various times.

Time (s)	Displacement (m)
0	0
1	12
2	24
3	36
4	48

What is the velocity of the body?
(A) 4 m/s
(B) 8 m/s
(C) 12 m/s
(D) 48 m/s

Ans : (C)

For uniform motion, velocity is the displacement divided by the time taken. It can be calculated from any data pair (other than the origin). For instance, at t=3 s, displacement is 36 m. Velocity = 36 m / 3 s = 12 m/s. This is consistent across all data points (e.g., 48 m / 4 s = 12 m/s).

26. Read the following statements regarding acceleration and retardation carefully:
I. Acceleration is a vector quantity having both magnitude and direction.
II. Retardation indicates that the velocity of the moving body is continuously increasing.
III. The position and negative signs of acceleration tell us the direction of motion.
IV. The acceleration of a freely falling body under gravity is universally considered uniform.
Which of the statements provided are strictly correct?
(A) I and IV
(B) II and III
(C) I, II and IV
(D) I, III and IV

Ans : (A)

Acceleration is indeed a vector quantity. Retardation strictly means the velocity is continuously decreasing, not increasing. Furthermore, positive and negative signs indicate whether velocity is increasing or decreasing, not the actual travel direction. Free fall exhibits constant gravitational acceleration.

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27. Suppose a train is moving continuously on a long, straight track with a perfectly uniform velocity of 60 km/h. What will be the acceleration of this train?
(A) 60 km/h squared
(B) Zero
(C) 10 m/s squared
(D) 9.8 m/s squared

Ans : (B)

Acceleration is defined exclusively as the rate of change of velocity over time. If a body moves with a perfectly uniform velocity, there is absolutely no change in its velocity, which mathematically results in the acceleration being exactly zero.

28. **Assertion (A) :** If two bodies of different masses are simultaneously dropped from the same height in a vacuum, both will reach the ground at exactly the same time.
Reason (R) : The value of acceleration due to gravity is heavily dependent on the mass of the falling body.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The assertion is fundamentally true because all objects fall with the exact same gravitational acceleration in a vacuum. The reason is completely false because the value of acceleration due to gravity is entirely independent of the falling body's individual mass.

29. The average value of acceleration due to gravity (g) is approximately 9.8 m/s^2 on the surface of the Earth. Which of the following statements

correctly describes how this value changes?
(A) It remains absolutely constant everywhere on Earth's surface and at all altitudes.
(B) It is perfectly minimum at the poles and maximum at the equator.
(C) It effectively decreases with an increase in altitude and depth from the Earth's surface.
(D) It rapidly increases linearly as one moves deep into a mine.

Ans : (C)

The value of acceleration due to gravity is not constant globally; it is maximum at the poles and minimum at the equator. Furthermore, this gravitational value consistently decreases as altitude increases and also as depth from the Earth's surface increases.

30. Displacement-time data for two athletes, Priya and Rohan, running a race is given below.

Time (s)	**Priya's Displacement (m)**	**Rohan's Displacement (m)**
0	0	0
2	12	16
4	24	32
6	36	48

Based on the data, which statement is correct?
(A) Priya is faster than Rohan.
(B) Rohan's velocity is 8 m/s.
(C) Priya's velocity is 12 m/s.
(D) Both have the same velocity.

Ans : (B)

Velocity can be calculated as displacement/time. Priya's velocity = 36 m / 6 s = 6 m/s. Rohan's velocity = 48 m / 6 s = 8 m/s. Since 8 m/s > 6 m/s, Rohan is faster than Priya. Option (B) correctly states Rohan's velocity. Options (A) and (D) are incorrect, and option (C) states an incorrect velocity for Priya.

31. In a standard displacement-time graph, the time is plotted on the X-axis and displacement on the Y-axis. What fundamental physical quantity is derived by calculating the slope of this graph?
(A) Total distance
(B) Acceleration
(C) Velocity
(D) Applied force

Ans : (C)

The slope of any mathematical graph is calculated as the ratio of the vertical change to the horizontal change. In a displacement-time graph, this ratio directly computes displacement divided by time, which perfectly defines the velocity of the moving body.

32. A body is kept perfectly stationary at a fixed distance from an initial reference point. How is this particular state represented on a displacement-time graph?
(A) A perfectly straight line inclined at an angle towards the time axis
(B) A straight line drawn perfectly parallel to the time axis
(C) A sharply curved line showing an exponential geometric upward trend
(D) A perfectly straight line drawn perpendicular to the time axis

Ans : (B)

When a body remains entirely at rest, its spatial displacement effectively does not change as time continuously progresses. This absolute lack of movement translates graphically into a horizontal straight line plotted completely parallel to the baseline time axis.

33. Match the graphical features in List-I with their correct physical interpretations in List-II.
List-I (Graph Feature)
P. Positive slope in a displacement-time graph
Q. Negative slope in a displacement-time graph
R. Positive slope in a velocity-time graph
S. Negative slope in a velocity-time graph
List-II (Physical Interpretation)
I. Uniform retardation
II. Uniform acceleration
III. Uniform motion away from the starting point
IV. Uniform motion towards the starting point
(A) P-III, Q-IV, R-II, S-I
(B) P-II, Q-I, R-III, S-IV
(C) P-IV, Q-III, R-I, S-II
(D) P-I, Q-II, R-IV, S-III

Ans : (A)

A positive slope in a displacement-time graph indicates uniform motion away from the origin. A negative slope means returning towards the origin. In velocity-time graphs, a positive slope represents uniform acceleration, whereas a negative slope represents uniform retardation.

34. In an accurately plotted velocity-time graph representing a moving object, what exact physical quantity is determined by calculating the total area enclosed between the velocity curve and the

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time axis?
(A) The overall uniform acceleration
(B) The precise rate of retardation
(C) The total displacement of the body
(D) The average uniform speed

Ans : (C)

Displacement is mathematically defined as the product of velocity and time. Therefore, calculating the geometric area enclosed between the plotted velocity-time graph line and the horizontal time axis accurately provides the total displacement of the moving body during that interval.

35. A body's motion is described by the velocity-time data in the table. The body starts from an initial velocity and is brought to rest.

Time (s)	Velocity (m/s)
0	20
5	20
10	0

What is the total displacement of the body in 10 seconds?
(A) 100 m
(B) 150 m
(C) 200 m
(D) 300 m

Ans : (B)

Displacement is the area under the velocity-time graph. From t=0 to t=5 s, the area is a rectangle: 5 s × 20 m/s = 100 m. From t=5 to t=10 s, the area is a triangle: ½ × base × height = ½ × (10-5) s × 20 m/s = 50 m. The total displacement is the sum of these areas: 100 m + 50 m = 150 m.

36. An acceleration-time graph is plotted with time on the X-axis and acceleration on the Y-axis. What specific physical parameter is accurately obtained by calculating the area enclosed under this graph?
(A) Total distance traveled
(B) Average velocity
(C) Change in velocity
(D) Final displacement

Ans : (C)

Acceleration is defined as the mathematical rate of change of velocity. Therefore, multiplying acceleration by time yields the change in velocity. The geometric area enclosed strictly between the acceleration-time graph and the time axis accurately represents this velocity change.

37. If a plotted velocity-time graph for a given moving body is an absolutely straight horizontal line parallel to the time axis, what specific conclusion can be drawn about its acceleration?
(A) The acceleration is completely uniform and strictly positive.
(B) The acceleration is entirely zero because velocity remains constant.
(C) The body experiences continuous uniform negative acceleration.
(D) The acceleration continuously increases at an exponential geometric rate.

Ans : (B)

A horizontal line on a velocity-time graph signifies that the object's velocity remains entirely constant as time passes. Since acceleration precisely measures the mathematical rate of change of velocity, a constant velocity inherently results in absolutely zero calculated acceleration.

38. A student mistakenly draws a displacement-time graph featuring a perfectly straight vertical line drawn strictly parallel to the displacement axis (Y-axis). Why is this specific graphical representation considered physically impossible?
(A) It implies the object's displacement is increasing infinitely without any progression in time.
(B) It implies the object is moving entirely backward towards its initial starting point.
(C) It implies the object possesses exactly zero absolute velocity.
(D) It implies the time is increasing but the displacement remains perfectly constant.

Ans : (A)

A vertical line strictly parallel to the displacement axis suggests that the object's displacement increases infinitely without any corresponding passage of time. This implies an infinitely high speed, which is a completely impossible scenario within all known physical laws.

39. A body initially starts moving with a velocity 'u' and accelerates uniformly with an acceleration 'a' for a specific time 't'. Which algebraic equation correctly represents its final acquired velocity 'v'?
(A) $v = u - at$
(B) $v = u + at$
(C) $v = ut + at$
(D) $v = a + ut$

Ans : (B)

By fundamental definition, acceleration is the exact rate of change of velocity. Calculating

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this change mathematically yields the relation $a = \frac{v-u}{t}$.

Rearranging this basic formula provides the standard first equation of uniformly accelerated motion: $v = u + at$.

40. The second equation of uniformly accelerated motion is expressed as $S = ut + \frac{1}{2}at^2$. In this standard mathematical equation, what exactly does the physical variable 'S' accurately represent?
(A) Total instantaneous speed
(B) Change in acceleration
(C) Distance traveled in time t
(D) The average starting velocity

Ans : (C)

In the fundamental kinematic equations of motion, the variable 'S' specifically denotes the total distance traveled or the precise displacement achieved by the moving body during the given time interval 't' while undergoing a perfectly constant uniform acceleration 'a'.

41. Evaluate the following statements regarding the motion of an object experiencing a pure free fall under the exclusive influence of Earth's gravity:
I. Its initial velocity is universally taken as exactly zero.
II. Its acceleration is strictly uniform and completely constant.
III. The final velocity reached is completely independent of the falling time.
IV. The relevant equation for calculating distance transforms precisely to $h = \frac{1}{2}gt^2$.

Which of these statements are considered scientifically true?
(A) I, II and IV
(B) II, III and IV
(C) I, III and IV
(D) I, II and III

Ans : (A)

A freely falling body uniformly starts exactly from rest, making its initial velocity zero. It accelerates at a completely constant rate denoted by 'g'. Consequently, the distance formula simplifies accurately to $h = \frac{1}{2}gt^2$.

Final velocity strictly depends on time.

42. **Assertion (A) :** The standard three equations of motion, such as $v = u + at$, can be utilized exclusively when a body moves with a perfectly uniform and constant acceleration.
Reason (R) : If a body's acceleration continuously changes over time, these simple algebraic equations fail to accurately predict the object's exact final velocity or total displacement.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The standard kinematic equations of motion are explicitly derived under the strict assumption that acceleration remains completely constant throughout the entire journey. Variable acceleration requires complex calculus methods because simple algebraic derivations break down when the rate of change fluctuates continuously.

43. When a stone is thrown vertically upwards into the open air, its moving velocity decreases continuously with time. What specific value of acceleration should logically be substituted into the standard equations of motion?
(A) + g
(B) - g
(C) Zero
(D) Infinite

Ans : (B)

When an object is propelled vertically upwards, it strictly moves directly against Earth's gravitational pull. Because gravity continuously slows the object down, it mathematically produces uniform retardation. Therefore, the specific acceleration value is designated accurately as negative gravity, or -g.

44. An athlete confidently runs straight from point A to point B with an average velocity of 20 m/s. He then instantly returns from B to A with an average velocity of 30 m/s. What is his total average velocity for this entire round trip?
(A) 25 m/s
(B) 24 m/s
(C) 0 m/s
(D) 10 m/s

Ans : (C)

Average velocity is strictly defined as total displacement divided by total time. Since the athlete returns precisely to his original starting point A, his overall final displacement is exactly zero. Consequently, his mathematically calculated average velocity for the entire trip is zero.

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45. A moving vehicle traveling safely at 20 m/s is brought to a complete halt by applying strict brakes that provide a uniform retardation of exactly 5 m/s^2. How much time does the vehicle require to finally stop?
(A) 5 seconds
(B) 4 seconds
(C) 10 seconds
(D) 2 seconds

Ans : (B)

The vehicle's initial velocity is twenty, its final velocity is zero, and its uniform acceleration is negative five. Applying the first equation of motion, v = u + at, we get 0 = 20 - 5t, which correctly solves to exactly 4 seconds.

46. A perfectly round ceiling fan continuously rotates strictly at a constant speed of 100 revolutions per minute. What specific physical effect does this continuous circular motion have on the overall velocity of the moving fan blades?
(A) The velocity remains entirely constant and perfectly uniform at all times.
(B) The velocity is accurately considered zero because displacement is zero.
(C) The velocity remains non-uniform solely due to the continuous change in motion direction.
(D) The velocity perfectly equals the speed because the blades cover equal distances.

Ans : (C)

Velocity is a specialized vector quantity strictly requiring both numerical magnitude and spatial direction. Even though the fan blades consistently maintain a constant rotational speed, their directional orientation changes continuously, which correctly causes the overall velocity to remain highly non-uniform.

ONE MARK QUESTIONS

47. Write the parameters required to express a scalar quantity.

Ans :
Magnitude only

48. Name the parameters required to express a vector quantity.

Ans :
Magnitude and direction.

49. What does the negative sign with a vector quantity indicates ?

Ans :
It indicates that the vector is in the opposite direction.

50. When is a body said to be at rest ?

Ans :
A body is said to be at rest when its position does not change with respect to its surroundings.

51. When is a body said to be in motion ?

Ans :
A body is said to be in motion when its position changes with respect to its surroundings.

52. What do you mean by motion in one direction ?

Ans :
The motion of a body is said to be in one dimension if it moves along a straight line path.

53. What does the slope of a displacement - time graph represent ?

Ans :
Slope of a displacement - time graph gives the velocity.

54. When can the distance-time and displacement-time graph be the same?

Ans :
When the body moves in a straight line without changing direction.

55. What information do we get by a greater slope of displacement - time graph?

Ans :
It indicates higher velocity (greater speed).

56. What information is conveyed about motion by the negative slope of a displacement-time graph?

Ans :
It indicates motion in the opposite direction (negative velocity).

57. What does the slope of velocity - time graph represent?

Ans :
Slope of velocity time graph represents acceleration.

58. What information do we get by a higher slope of velocity - time graph?

Ans :
It indicates greater acceleration.

59. What information do we get about motion by the negative slope of a velocity - time graph?

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Ans :
It indicates negative acceleration (retardation).

60. How is the distance related with time for the motion under uniform acceleration such as the motion of a freely falling body ?

Ans :
Distance (S) is related directly to the square of time(t^2) i.e. $S \propto t^2$

61. Define displacement. State its unit.

Ans :
Displacement is the shortest distance between the initial and final position of a body in a given direction.
Units : S.I unit is metre (m)

62. Which of the quantity speed or velocity gives the direction of motion of body ?

Ans :
The direction of motion of a body is given by its velocity because it is speed of a body in a specified direction.

63. When is the magnitude of displacement equal to the distance?

Ans :
The magnitude of displacement is equal to the distance when the body moves along a fixed direction.

64. What is meant by the term retardation ? Name its S.I. unit.

Ans :
When the velocity of a body decreases with time, it is said to be under retardation.
Units : S.I. unit of retardation is m s^{-2}

65. When is the instantaneous speed same as the average speed?

Ans :
The instantaneous speed is the same as the average speed when the body moves with uniform speed.

66. Define the term acceleration due to gravity. State its average value.

Ans :
When a body is falling freely, the acceleration possessed by it is called acceleration due to gravity (g)
Average value of 'g' = 9.8 ms^{-2} Or 980 cm s^{-2}

67. Define velocity. State its units.

Ans :
"Rate of change of displacement with time" is called velocity.

$$V = \frac{\text{distance}}{\text{time}}$$

Units S.I. unit is ms^{-1} C.G.S. unit it cms^{-1}

68. Which of the quantity velocity or acceleration determines the direction of motion ?

Ans :
Out of velocity and acceleration, the direction of motion of the body is determined by its velocity because acceleration simply tells us the rate at which the velocity of a body changes.

69. Define speed. What is its S.I. unit ?

Ans :
The distance covered by a body in a unit time is called its speed. It is also defined as the rate of change position of a body in any direction. Thus, distance.

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

The SI unit of speed is meter/second or ms^{-1}

70. Define acceleration. State its S.I. unit.

Ans :
"Rate of change of velocity with respect to time" is called acceleration.

$$\text{Acceleration} = \frac{\text{velocity}}{\text{time}}$$

$$= \frac{v}{t}$$

Units : S.I. unit of acc. is m s^{-2}
In C.G.S., unit of acc. is cms^{-2}

71. For the motion with uniform velocity, how is the distance travelled related to the time ?

Ans :
For a body moving with uniform velocity, the displacement (distance from the starting point) is directly proportional to the time.
$S \propto t$

TWO MARKS QUESTIONS

72. 'The value of g remains same at all places on the earth surface'. Is this statement true ? Give reason for your answer.

Ans :

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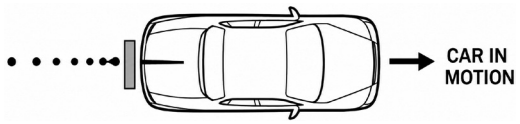
No. The value of g is maximum at poles and minimum at equator.
Since polar distance is less than equatorial distance
and $g = \frac{MG}{R^2}$

13. Give an example of motion in which average speed is not zero, but the average velocity is zero'.

Ans :
If a body starts its motion from a point and comes back to the same point after a certain time,
then its average velocity $\left(\frac{\text{displacement}}{\text{time}}\right)$ is zero
but its average speed $\left(\frac{\text{distance}}{\text{time}}\right)$ is not zero.

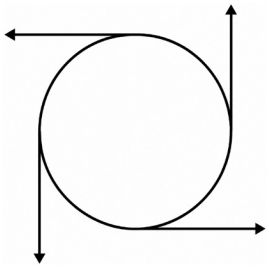
14. The diagram below shows the pattern of the oil dripping on the road, at a constant rate from a moving car. What informations do you get from it about the motion of car ?



Ans :
The motion of car is dimensional (or rectilinear) motion. As it is clear from the fig, that car is moving on a long and straight road. Initially it is moving with a constant speed and then it slows down.

15. Give an example of the motion of a body moving with a constant speed but with a variable velocity. Draw a diagram to represent such a motion.

Ans :
A body moving in a circle with constant speed but variable velocity as the velocity of the body at any point is along the tangent to the circle at that point as shown in the figure.



16. Write three equations of uniformly accelerated motion relating the initial velocity (u), final velocity (v), time (t), acceleration (a) and displacement (S).

Ans :
Three equations connecting, u, v, a, t and S are

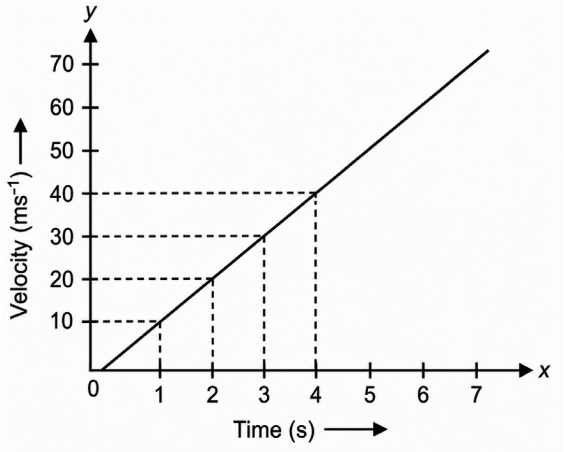
(i) $v = u + at$

(ii) $v^2 - u^2 = 2aS$

(iii) $S = ut + \frac{1}{2}at^2$

17. Draw a velocity-time graph for the free fall of a body under gravity, starting from rest. Take g = 10 ms^{-2}

Ans :
Velocity-time graph for a freely falling body under the gravity is as follows :



18. Can displacement be zero even if distance is not zero ? Give one example to explain your answer.

Ans :
Yes, displacement of a body can be zero even if the distance covered by it is not zero. For example, if a body moves in a circle, then displacement of the body in one rotation is zero but the distance covered by it in one rotation $2\pi r$, where r is the radius of the circle in which the body is moving. Give an example of motion in which average speed is not zero, but the average velocity is zero.

THREE MARKS QUESTIONS

19. If a stone and a pencil are dropped simultaneously in vacuum from the top of a tower. Which of the two will reach the ground first ? Give reason.

Ans :
Both will reach the ground simultaneously, since acceleration is same (= g) on both.
and $g = \frac{MG}{R^2}$
the expression is independent of the mass of body.

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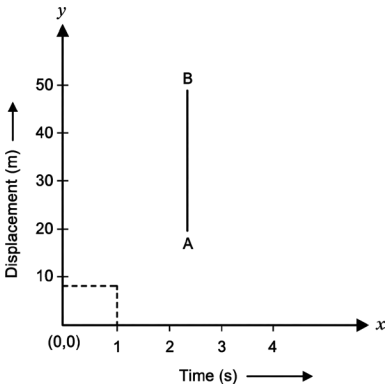
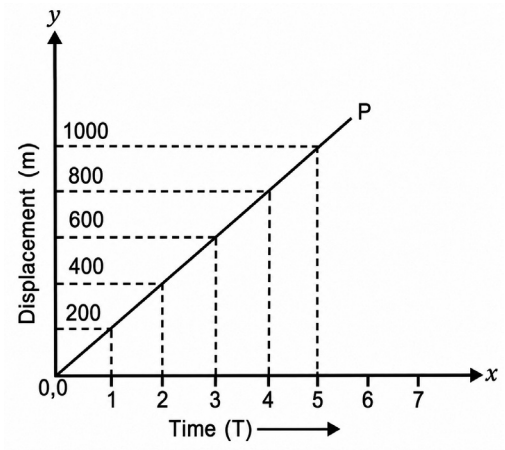
80. Can displacement - time sketch be parallel to the displacement axis ? Give reason to your answer.

Ans :
Displacement - time graph cannot be a straight line parallel to displacement axis, this would mean that the distance covered by the body in a certain direction is increasing without any increase in time i.e., the velocity of the body is infinite which is impossible.



81. Draw a displacement - time graph for a boy going to school with uniform velocity.

Ans :
Let the boy going to school has uniform velocity of 200 m/minute and his school is situated 1 km (1000 m) away. The graph shows his displacement with time.

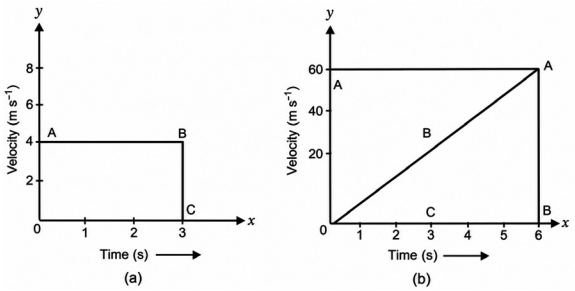


82. What can you say about the nature of motion of a body if its displacement - time graph is :-
(a) a straight line parallel to time axis?
(b) a straight line inclined to the time axis with an acute angle.?
(c) a straight line inclined to the time axis with an obtuse angle?
(d) a curve.

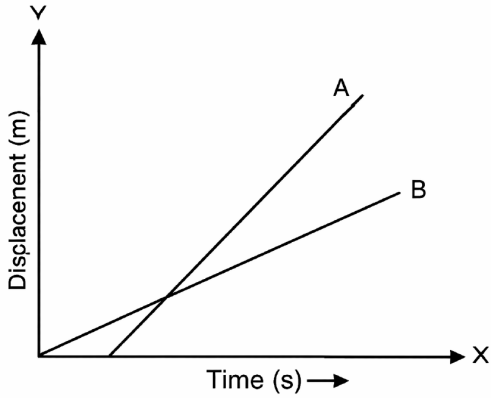
Ans :
(a) body is stationary (or no motion).
(b) motion away from the starting point with uniform velocity.
(c) motion towards the starting point with uniform velocity.
(d) motion with variable velocity.

83. Draw the shape of the velocity - time graph for a body moving with (a) uniform velocity, (b) uniform acceleration.

Ans :
(a) Velocity - time graph for a body moving with uniform velocity.
(b) Velocity - time graph for a body moving with uniform acceleration.



84. Figure shows displacement time graphs of two vehicles A and B moving along a straight road. Which vehicle is moving faster ? Give reason.



Ans :

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}, \text{ so speed } \propto \text{ distance.}$$

As vehicle , A displaces more than B, so vehicle A is moving faster.
Reason : Slope of line A is more than that of line B.

85. State whether the following quantity is a scalar or vector ?

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(a) pressure (b) force
(c) momentum (d) energy
(e) weight (f) speed.

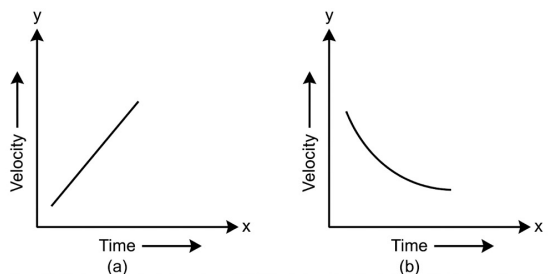
Ans :
(a) Pressure is a scalar quantity because it has magnitude and no direction.
(b) Force is a vector quantity because it has both magnitude as well as direction.
(c) Momentum = mass × velocity, is a vector quantity because it has both magnitude as well as direction.
(d) Energy is a scalar quantity because it has magnitude and no direction.
(e) Weight is a vector quantity because it is the force with which a body is attracted towards the centre of the earth.
(f) Speed is a scalar quantity because it has magnitude and no direction.

86. Differentiate between the scalar and vector quantities, giving two examples of each.

Ans :
The difference between the scalar and vector quantities are as follows :

	VECTORS	SCALARS
1.	Vectors are specified by two quantities (i) magnitude and (ii) direction.	Scalars are specified by one quantity only i.e. magnitude.
2.	Vectors change when there is change in either magnitude or direction or both.	Scalars change by change in magnitude along.
3.	Vectors are written (shown) in bold face letters or letters having arrows heads on them.	Scalars are written or represented by ordinary letters.

87. State the type of motion represented by the following sketches in Figure (a) and (b).



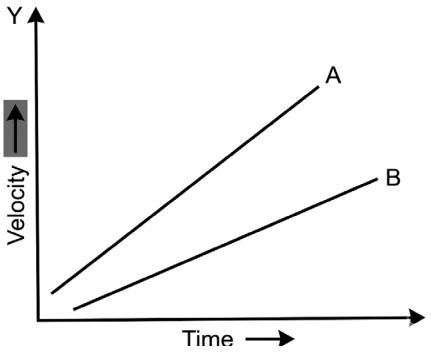
Give example of each type of motion.

Ans :
(a) Velocity - time graph of a body moving with accelerated motion whose initial velocity is not zero : Example : a train moving with 40 km/hr, accelerates at ihe rate of 5 kmh^{-2} for 3 hours.
(b) Velocity - time graph shows that velocity decreases with time and velocity is non - uniform.
Example : A moving train at 80 km/hr. Brakes are applied to stop it at approaching station.

88. Figure shows the velocity-time graph for two cars A and B moving in same direction. Which car has the greater acceleration ? Give reason to your answer.

Ans :

We know, acceleration $= \frac{\text{velocity}}{\text{time}}$



So, acceleration $\propto$ velocity.
As car B has greater velocity than A. So, car B has greater acceleration.
Reason : Slope of line B is more than that of line A.

89. The velocity - time graph for a uniformly retarded body is a straight line inclined to the time axis with an obtuse angle. How is retardation calculated from the velocity - time graph?

Ans :
Retardation is calculated by finding negative slope of line BC $= -\frac{BD}{DC} = \frac{(o - v)\,ms^{-1}}{(t_2 - t_1)\,sec}$

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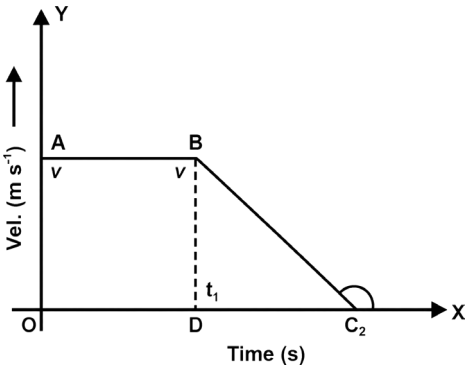
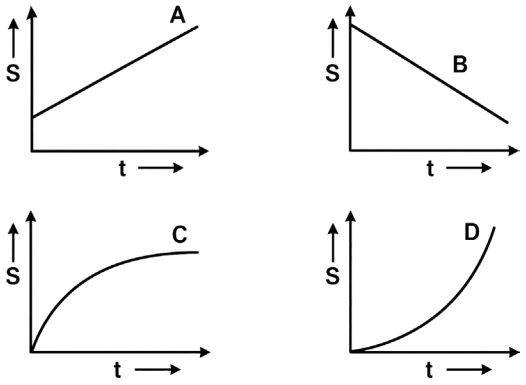


90. Figure shows the displacement - time graph for four bodies A, B, C and D. In each case state what information do you get about the acceleration (zero, positive or negative).



Ans :

A : Zero acceleration since slope (i.e., velocity) is constant,

B : Zero acceleration since slope is constant,

C : Negative acceleration (or retardation) since slope is decreasing with time,

D : Positive acceleration since slope is increasing with time.

91. What is the direction of velocity of an object moving in a circular path?

Ans :

The direction of the velocity of an object moving in a circular path changes continuously as the object moves along the path. At any given point on the circular path, the direction of the velocity vector is tangent to the circle and points in the direction of the motion of the object at that point. Specifically, the velocity vector of an object moving in a circular path is always perpendicular to the radius vector of the circle at the point where the object is located. This is because the velocity vector represents the instantaneous direction of the motion of the object, which is always tangent to the path, while the radius vector points from the center of the circle to the object. Thus, the direction of the velocity vector of an object moving in a circular path is constantly changing as the object moves along the path, always pointing in the direction of the tangent to the circle at that point.

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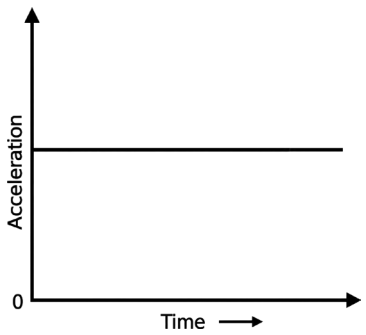
92. Draw a graph for acceleration against time for a uniformly accelerated motion. How can it be used to find the change in speed in a certain interval of time ?

Ans :

Graph for acceleration against time for a uniformly accelerated motion is shown as below :



In this graph, time is taken on x - axis and acceleration is taken on y - axis. Since acceleration

$$= \frac{\text{velocity}}{\text{time}}$$

Acceleration $\times$ time = change in speed

Therefore, in the given graph the area enclosed between the acceleration - time sketch and the time axis gives the change in speed of body.

93. Write an expression for the distance S covered in time t by a body which is initially at rest and starts moving with a constant acceleration a.

Ans :

Let the body covers a distance S in t sec. In doing so its velocity increases v ms^{-1}

$$\text{Average velocity} = \frac{S}{t} \qquad \text{...(i)}$$

$$\text{Also average velocity} = \frac{u+v}{2} \qquad \text{...(ii)}$$

$$\frac{S}{t} = \left(\frac{u+v}{2}\right)$$

$$S = \left(\frac{u+v}{2}\right) \times t$$

but $v\ u + at$

$$S = \left[\frac{u+(u+at)}{}\right] \times t$$

$$\left(\frac{ut+ut+at^2}{2}\right)$$

$$= \left[\frac{2ut}{2} + \frac{at^2}{2}\right]$$

But inital vel. $u = 0$

$$S = \left[0 + \frac{at^2}{2}\right]$$

$$= \frac{at^2}{2}$$

Expression for distance covered $= \frac{1}{2}$ acceleration $\times$ (time)^2

94. State how the velocity - time graph can be used to find

(i) the acceleration of a body,

(ii) the distance travelled by the body in a given time, and

(iii) the displacement of the body in a given time.

Ans :

(i) Acceleration of a body from the velocity - time graph.

Since acceleration $= \frac{\text{velocity}}{\text{time}}$

Slope of the velocity - time graph gives the acceleration.

(a) If the slope is positive, it is accelerated motion.

(b) If slope is negative,the acceleration is negative and the motion is retarded.

(c) If the slope is zero i.e. velocity - time graph is a straight line parallel to x - axis then acceleration is zero.

(ii) The distance travelled by the body in a given time can be obtained by finding the area enclosed between the velocity - time graph and x -axis give displacement of the body.

Total distance travelled by body is their arithmetic sum (without sign) but total displacement is obtained by adding them numerically.

95. How is the velocity obtained from the displacement - time graph for a body moving with a varying speed in a fixed direction ?

Ans :

If a body is moving with a varying speed in a fixed direction, the velocity can be obtained from the displacement-time graph by calculating the slope of the tangent to the curve at any point. The slope of the tangent to the curve represents the instantaneous velocity of the body at that point.

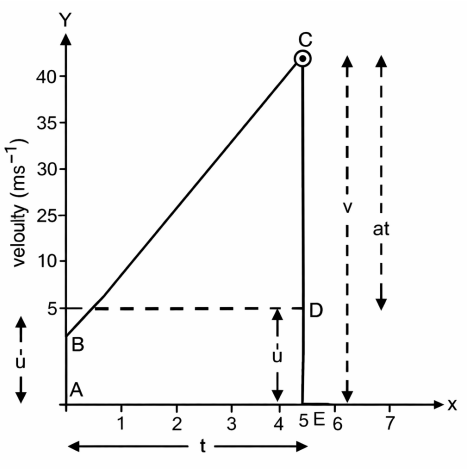
To find the slope of the tangent at a particular point, draw a straight line that touches the curve at that point. The slope of this line represents the velocity of the body at that instant. This slope can be calculated by taking the ratio of the change in displacement over a small time interval around that point.

Alternatively, if the displacement - time graph is a smooth curve, the average velocity of the body can be calculated over a specific time interval by finding the total change in displacement over that interval and dividing it by the time interval.

However, if the displacement - time graph has sudden changes in direction or the speed of the body changes rapidly, the instantaneous velocity should be calculated using the slope of the tangent at that point.

96. Draw a velocity - time graph for a body moving with initial velocity u and uniform acceleration a. Use this graph to find the distance travelled by the body in time t.

Ans :



Distance travelled by body in time t = Area under BC = area of trapezium ABCE

$$S = \frac{1}{2}AE[\,AB + CE\,]$$

$$= \frac{1}{2}t[\,u + v\,]$$

But $v = u + at$

$$S = \frac{1}{2}t[\,u + u + at\,]$$

$$S = \frac{1}{2}t[\,2u + at\,]$$

$$= ut + \frac{1}{2}at^2$$

97. A body falls freely from a certain height. Show graphically the relation between the distance fallen and square of time. How will you determine g from this graph ?

Ans :

For a uniformly accelerated motion, the displacement is directly proportional to the

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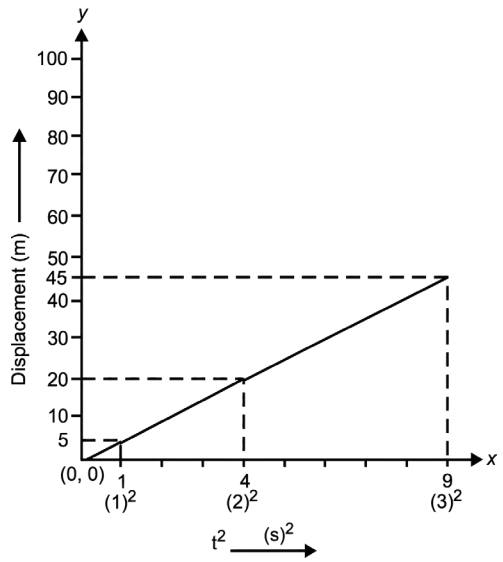
square of time [$S \propto t^2$].
Hence a graph plotted for displacement (S) versus square of time (t^2) will be a straight line with slope equal to half of the acceleration.

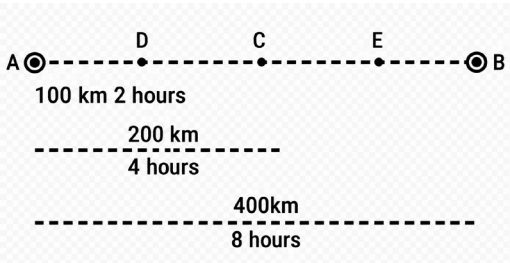
$$h = \frac{1}{2}gt^2$$

The value of (g) can be calculated by $g = \frac{2h}{t^2}$ or by taking double the slope of graph plotted for (S) fallen versus (t^2).



98. Give one example of each type of following motion:
(i) uniform velocity
(ii) variable velocity
(iii) variable acceleration
(iv) uniform retardation.

Ans :
(i) Uniform Velocity :
Example (1) :



Suppose two stations A and B are 400 km apart and a car moving with uniform velocity of 50 km/hr from station A covers this distance in 8 hours keeping the direction same. If we check after 4 hours, it should have reached C covering a distance of 200 km and reached D in two hours covering a distance of 100 km keeping the direction always same'

Example (2) : Rotation of earth around the sun'

(ii) Variable velocity :
Examples :
(1) A body moving in a circular path' has variable velocity as its direction changes at every point.
(2) A car turning a corner at constant speed has variable velocity'

(iii) Variable acceleration :
Examples :
(1) A body proiected vertically upwards has variable acceleration'
(2) A scooter driven on a crowded city road with frequent application of brakes has variable acceleration.

(iv) Uniform retardation : A uniform negative acceleration is called uniform retardation. Example : If brakes are applied on a train approaching a station to stop it and the retardation is uniform i.e. it slows down by equal rate of change of velocity, then this retardation is uniform retardation.

99. Differentiate between the following :
(a) distance and displacement.
(b) speed and velocity
(c) uniform velocity and variable velocity.
(d) average speed and average velocity.
(e) acceleration and retardation.
(f) Uniform acceleration and Variable acceleration

Ans :
(a) Differences between distance and displacement are as follows :

	Distance	**Displacement**
1.	It is a scalar quantity.	It is a vector quantity.
2.	Distance travelled is always positive.	Displacement may be positive negative or zero.
3.	The distance travelled by a moving body is the actual length of path.	The displacement of a body is the shortest distance between the initial and final positions of the body.
4.	Distance travelled is always greater than or equal to the displacement.	Displacement is always less than or equal to the distance travelled.

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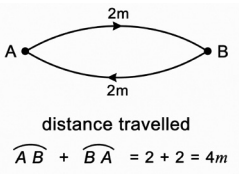
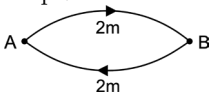
5.		Displacement is zero  The initial point and final point is same.

(b) The difference between speed and velocity are as follows :

	Speed	**Velocity**
1.	The rate of change of position of a body in any direction is known as its speed	The rate of change of position of a body in a particular direction is known velocity.
2.	It is a scalar quantity.	It is a vector quantity
3.	It can be positive or zero.	It can be positive, negative or zero

(c) The difference between uniform velocity and variable velocity are as follows :

	Uniform velocity	**Variable velocity or Non-uniform velocity**
1.	When a body covers equal distances in a straight line, in equal intervals of time.	When a body covers unequal distances in equal intervals of time in a straight line.
2.	In this case direction of motion remains the same.	In this case direction of motion changes.
3.	Example : A body moving with a constant speed in a straight line has uniform velocity.	Example : Circular motion is example of variable velocity.

(d) The difference between average speed and average velocity are as follows :

	Average Speed	**Average Velocity**
1.	It is the ratio of total distance travelled by the body to total time taken to travel that distance. Average Speed $= \frac{\text{Total dist. travelled}}{\text{Total time taken}}$	If the velocity of a body changes continuously at a uniform rate in a particular direction, the average of the initial and final velocities over a given period of time is called average velocity. If u is the initial velocity and v is the final velocity in a particular direction. Average Velocity $= \frac{u+v}{2}$
2.	It is a scalar quantity.	It is a vector quantity.
3.	For a body moving in a circular path, the instantaneous speed and the average speed are equal but not zero.	For a body moving in circular path, the displacement for one rotation is zero and hence average velocity is zero.

(e) The difference between acceleration and retardation area s follows :

	Acceleration	**Retardation**
1.	Rate of change of velocity with time is called acceleration $= \frac{\text{velocity}}{\text{time}}$	When the velocity of a body decreases with time, it is said to be under retardation.
2.	A body falling towards the earth has positive acceleration,	A ball thrown vertically upwards has retardation or de-acceleration.

(f) Uniform acceleration and Variable acceleration are as follows :

	Uniform acceleration	**Variable acceleration**
1.	If equal changes in velocity take place in equal intervals of time, the acceleration is called uniform acceleration.	If the rate of change of velocity is different at different points of time during its motion, the body has variable acceleration.

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2.	The velocity-time graph of a body having uniform acceleration is a straight line.	The velocity-time graph of a body with non-uniform acceleration is a curved line.
3.	Example : The motion of a body under gravity.	Example : A body projected vertically upwards.

FOUR MARKS QUESTIONS

100. Both scalar and vector quantities can be added, subtracted, multiplied and divided by simple arithmetic methods. Is this statement correct? Give a reason for your answer.

Ans :

The statement that "both scalar and vector quantities can be added, subtracted, multiplied and divided by simple arithmetic methods" is partially correct. Scalar quantities can be added, subtracted, multiplied, and divided using simple arithmetic methods, but vector quantities require more complex methods to perform these operations.

Scalar quantities are represented by a single real number, which can be manipulated using simple arithmetic methods such as addition, subtraction, multiplication, and division. For example, if we have two scalar quantities, such as mass or temperature, we can add them together simply by adding their numerical values.

Vector quantities, on the other hand, have both magnitude and direction, and cannot be manipulated using simple arithmetic methods. In order to add, subtract, multiply, or divide vector quantities, we must use more complex methods such as vector algebra or the use of vector components.

For example, to add two vectors, we cannot simply add their numerical values as we would with scalars. Instead, we must add their components in each direction separately, taking into account the direction and magnitude of each vector. Similarly, to multiply or divide two vectors, we must use more complex methods such as the dot product or cross product of the vectors.

So while scalar quantities can be added, subtracted, multiplied, and divided using simple arithmetic methods, vector quantities require more complex methods to perform these operations.

101. Derive following equations for a uniformly accelerated motion:

(i) $v = u + at$

(ii) $S = ut + \frac{1}{2}at^2$

(iii) $v^2 = u^2 + 2aS$

where the symbols have their usual meanings.

Ans :

(i) Let a body moving with initial velocity u

After t sec acquires vel. v

Changes in velocity in t sec $= v - u$

and rate of change of velocity $= \frac{v-u}{t}$

But according to definition acceleration is equal to rate of change of velocity

$$\frac{v-u}{t} = a$$
$$v - u = at$$
$$v = u + at$$

(ii) $S = ut + \frac{1}{2}at^2$

We know that average velocity

$$= \left(\frac{\text{Initial velocity} + \text{final velocity}}{2}\right)$$

Average vel. $= \frac{u+v}{2}$ ...(i)

Also ay. vel $= \frac{\text{distance travelled}}{\text{time taken}} = \frac{S}{t}$ ...(ii)

From (i) and (ii)

$$\frac{S}{t} = \frac{u+v}{2}$$
$$S = \left(\frac{u+v}{2}\right) \times t$$

But $v = u + at$

$$S = \left[\frac{u+u+at}{2}\right]$$
$$= \frac{2ut + at^2}{2} = \frac{2ut}{2} + \frac{at^2}{2}$$
$$S = ut + \frac{1}{2}at^2$$

(iii) $v^2 = u^2 + 2as$

We know that average velocity $= \frac{\text{distance}}{\text{time}}$

$$\frac{S}{t} = \frac{u+v}{2}$$
$$S = \left(\frac{u+v}{2}\right) \times t \quad \text{...(i)}$$

But $v = u + at$

or $\frac{v-u}{a} = t$

$$S = \left[\frac{(v+u)}{2}\right]\left[\frac{v-u}{a}\right] \text{ put in} \quad \text{...(i)}$$
$$S = \frac{v^2 - u^2}{2a}$$

or $v^2 - u^2 = 2aS$

$v^2 = u^2 + 2aS$

102. Draw the velocity - time graphs for a body moving with :

(a) Uniform velocity

(b) Uniform acceleration

and give one example of each and also calculate the displacement and acceleration.

Ans :

(a) If a body is in motion with uniform velocity (i.e., velocity remains constant with time), the velocity-time graph is a straight line parallel to the time axis.

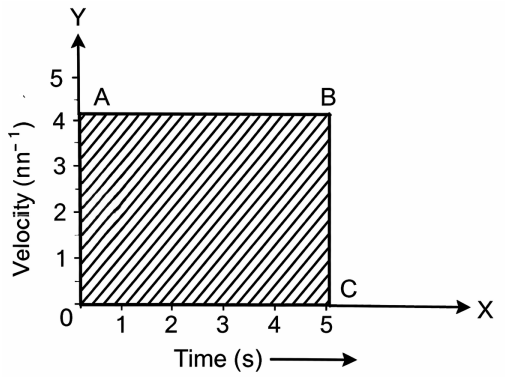


Figure : Velocity - time graph for uniform velocity

Example : In figure a straight line AB represents the velocity - time graph of a body moving with a uniform velocity 4 m s^{-1} for 5 s. The slope of the straight line AB is zero, therefore, its acceleration is zero.

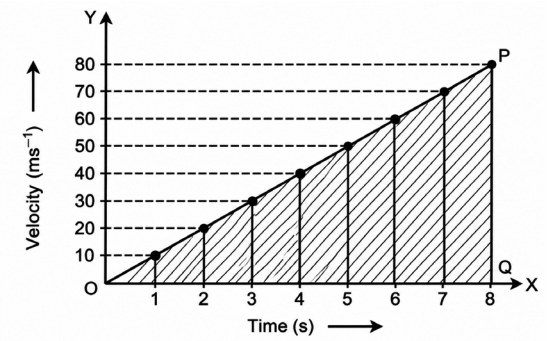
Displacement in 5 second = area of the rectangle OABC = OC × OA = 5 s × 4 ms^{-1} = 20 m.

(b) If the body is in motion with uniform acceleration (i.e., equal changes in velocity take place in equal intervals of time), the velocity - time graph is a straight line inclined to the time axis. The slope of the line gives the acceleration.

Example : The table below represents the velocity of a body at different instants, starting from rest.

Time (in s)	0	1	2	3	4	5	6	7	8
Velocity (in ms^{-1})	0	10	20	30	40	50	60	70	80

Obviously, the velocity is increasing by an equal amount in each second i.e., the body is moving with uniform acceleration. The velocity - time graph is a straight line OP inclined to the time axis as shown in fig.



Velocity - time graph, velocity increasing by an equal amount in each second

Distance travelled by the body in 8 second

S = area of triangle OPQ

$$= \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times \text{OQ} \times \text{QP}$$

$$= \frac{1}{2} \times 8\,\text{s} \times 80\,\text{ms}^{-1}$$

$$= 320\ \text{m}.$$

Acceleration of the body = Slope of the line OP

$$= \frac{\text{PQ}}{\text{QO}} = \frac{(80-0)\,\text{ms}^{-1}}{(8-0)\,\text{s}}$$

$$= \frac{80\,\text{ms}^{-1}}{8\,\text{s}} = 10\,\text{ms}^{-2}$$

103. Draw the acceleration - time graph for a body moving with :

(a) Uniform velocity

(b) Free falling body and give an example of each.

Ans :

(a) If the body is stationary or if it is moving with a uniform velocity, the acceleration is zero. The acceleration - time graph in such a case is a straight line coinciding with the time axis.

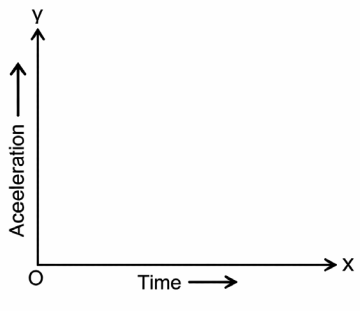


Figure : Acceleration - time graph for motion with uniform velocity

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(b) A body falling freely under gravity moves with a uniform acceleration of 9.8 m (or nearly 10 ms^{-2}). For a body moving vertically upwards, there is a unifi9rm retardation of 9.8 m s^{-2}. Thus motion under gravity is an example of uniformly accelerated or uniformly retarded motion.

Here we shall consider the motion of a freely falling body under gravity and we shall use the acceleration-time graph to obtain the velocity - time graph and the displacement - time graph. The acceleration-time graph for such a motion is a straight line parallel to the time axis.

In Fig straight line AF represents the acceleration - time graph for a body falling freely (or moving) with uniform acceleration equal to 10 ms^{-2}.

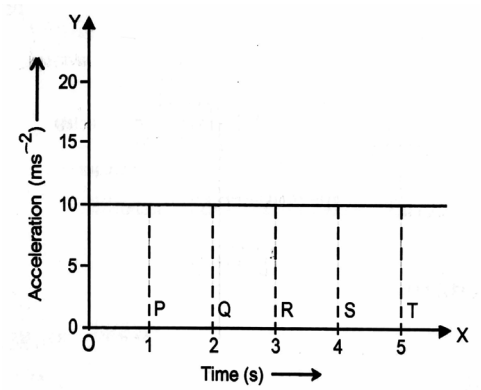

Figure : Acceleration - time graph for a freely falling body

This graph can be used to obtain the velocity - time graph, by finding the area enclosed between the straight line and the time axis for each interval of time of 1 s. Let the initial velocity at $t = 0$ be zero, then

$$\text{Velocity after 1s} = \text{Area OABP} = 10 \times 1 = 10 \text{ ms}^{-1}$$

$$\text{Velocity after 2 s} = \text{Area OACQ} = 10 \times 2 = 20 \text{ ms}^{-1}$$

$$\text{Velocity after 3 s} = \text{Area OADR} = 10 \times 3 = 30 \text{ ms}^{-1}$$

$$\text{Velocity after 4 s} = \text{Area OAES} = 10 \times 4 = 40 \text{ ms}^{-1}$$

$$\text{Velocity after 5 s} = \text{Area OAFT} = 10 \times 5 = 50 \text{ ms}^{-1}$$

NUMERICAL QUESTIONS

104. Express each of the following in ms^{-1} :
(a) 10 km h^{-1} (b) 18 km min^{-1}

Ans :

(a) $10 \text{ Km h}^{-1} = \dfrac{10 \times 1000}{60 \times 60}$

$= 2.78 \text{ ms}^{-1}$

(b) $18 \text{ Km min}^{-1} = \dfrac{18 \times 1000}{60} \text{ms}^{-1}$

$= 300 \text{ ms}^{-1}$

105. The speed of a car is 72 km h^{-1}. Express it in ms^{-1}.

Ans :

We know that, 1 km = 1000 m

1 hour = 3600 s

$$\frac{1 \text{ km}}{1 \text{ hr}} = \frac{1000 \text{ m}}{3600 \text{ s}}$$

$$\frac{1 \text{ km}}{1 \text{ hr}} = \frac{10 \text{ m}}{36 \text{ s}}$$

so, $$\frac{72 \text{ km}}{1 \text{ hr}} = \frac{10 \text{ m}}{36 \text{ s}} \times \frac{1 \text{ hr}}{1 \text{ km}} \times \frac{72 \text{ km}}{1 \text{ hr}}$$

$$= 20 \text{ ms}^{-1}$$

$$72/\text{km/hr} = 20 \text{ m/s}$$

or $$72 \times \frac{5}{12} = 20 \text{ ms}^{-1}$$

106. Arrange the following speeds in increasing order: 10 ms^{-1}, 1 km min^{-1}, 18 km h^{-1}

Ans :

To arrange the speeds in increasing order, first we are to change their units to equalize them.

(i) 10 ms^{-1}

(ii) $1 \text{ km min}^{-1} = \dfrac{1 \times 1000}{60} \text{ ms}^{-1} = 16.65 \text{ ms}^{-1}$

(iii) $18 \text{ km h}^{-1} = \dfrac{18 \times 1000}{60 \times 60} \text{ ms}^{-1} = 5 \text{ ms}^{-1}$

Increasing order = 5 ms^{-1} > 10 ms^{-1} > 16.65 ms^{-1} i.e. 18 km h^{-1}, 10 ms^{-1}, 1 km min^{-1}

107. A train takes 3 hours to trave from Agra to Delhi with a uniform speed of 65 km $hour^{-1}$. Find the distance between the two cities

Ans :

$t = 3$ hrs.

Speed, $v = 65$ km/hr

Distance, s = ?

$$v = \frac{\text{distance}}{\text{time}} = \frac{s}{t}$$

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$$s = v \times t$$

$$\text{Distance (s)} = 65 \times 3 = 195\,\text{km}$$

108. A body starts from rest and acquires a velocity 10 ms^{-1} in 2 s. Find the acceleration.

Ans :

Given,

$$u = 0, \quad \text{body starts from rest}$$
$$v = 10\,\text{ms}^{-1}$$
$$t = 2\,\text{sec}$$
$$a = ?$$
$$v = u + at$$
$$2a = 10$$
$$a = \frac{10}{2}$$
$$= 5\,\text{ms}^{-2}$$

109. A body starts from rest with a uniform acceleration 2 ms^{-2}. Find the distance covered by the body in 2s.

Ans :

We know $s = ut + \frac{1}{2}at^2$

Here, $u = 0,$

$$a = 2\ \text{ms}^{-2},$$
$$t = 2s$$
$$S = 0(2) + \frac{1}{2} \times 2(2)^2$$
$$= \frac{1}{2} \times 2 \times 4 = 4\text{m}$$

110. A bicycle initially moving with a velocity 5.0 ms^{-1} accelerates for 5 s at a rate of 2 ms^{-2}. What will be its final velocity?

Ans :

Initial velocity $u = 5.0\,\text{ms}^{-1}$

$$t = 5\,\text{sec}$$
$$a = 2\,\text{ms}^{-2}$$

Final velocity $v = ?$

$$v = u + at$$
$$v = 5 + 2 \times 5$$
$$= 15\,\text{ms}^{-1}$$

111. A car starting from rest acquires a velocity 180 ms^{-1} in 0.05 h. Find the acceleration.

Ans :

Given ; $u = 0;$

$$v = 180\,\text{ms}^{-1}$$
$$t = 0.05$$
$$h = 0.05 \times 60 \times 60\,\text{s}$$
$$= 180\,\text{s}$$
$$a = ?$$

Using $v = u + at,$

we get $a = \frac{v - u}{t}$

$$= \frac{180 - 0}{180}\,\text{ms}^{-2}$$
$$= 1\,\text{ms}^{-2}$$

112. A body is moving vertically upwards. Its velocity changes at a constant rate from 50 ms^{-1} to 20 ms^{-1} in 3 s. What is its acceleration?

Ans :

Given, $u = 50\,\text{ms}^{-1}$

$$v = 20\,\text{ms}^{-1}$$

and $t = 3\,\text{s}$

Acceleration, $a = \frac{v - u}{t}$

$$= \frac{20 - 50\,\text{ms}^{-1}}{3}$$
$$= \frac{-30}{3}$$
$$= -10\,\text{ms}^{-2}$$
$$a = -10\,\text{ms}^{-2}$$

The negative sign shows that the direction of acceleration is opposite to the direction of motion. The motion is upward, so acceleration is downwards.

113. A car accelerates at a rate of 5 ms^{-2}. Find the increase in its velocity in 2 s.

Ans :

Given

Initial velocity, $u = 0,$

Acceleration, $a = 5\,\text{ms}^{-2},$

$$t = 2\text{s}$$

Increase in velocity, $v = ?$

Using $v = u + at,$

we get $v = 0 + 5\,\text{m}^{-2} \times 2\text{s}$

$$= 10\,\text{ms}^{-1}$$

114. A car is moving with a velocity 20 ms^{-1}. The brakes are applied to retard it at a rate of 2 ms^{-2}. What will be the velocity after 5s of applying the

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brakes?

Ans :

$$u = 20\ \text{ms}^{-1}$$
$$a = -2\ \text{ms}^{-2}$$
$$t = 5\ \text{s}$$
$$v = ?$$
$$v = u + at$$
$$= 20 + (-2) \times 5$$
$$v = 20 - 10$$
$$= 10\ \text{ms}^{-1}$$

115. A body starts with an initial velocity of 10 ms^{-1} and acceleration 5 ms^{-2}. Find the distance covered
by it in 5 s.

Ans :

Given $u = 10\ \text{ms}^{-1}$,

$a = 5\ \text{ms}^{-2}$

and $t = 5\ \text{s}$

distance $s = ?$

$$s = ut + \frac{1}{2}at^2$$
$$= (10 \times 5) + \frac{1}{2} \times 5 \times 5 \times 5$$
$$= 50 + 62.5 = 112.5\ \text{m}$$

116. A stone is dropped freely from the top of a tower and it reaches the ground in 4 s. Taking $g = 10\ \text{ms}^{-2}$, calculate the height of the tower.

Ans :

Here $u = 0$,

$t = 4\ \text{sec},$,

$g = 10\ \text{ms}^{-2}$,

$h = ?$

Using, $h = ut + \frac{1}{2}gt^2$

$$h = (0 \times 4) + \frac{1}{2} \times (4 \times 4)$$
$$= 0 + 80$$
$$h = 80\ \text{m}$$

Height of tower $= 80\ \text{m}$

117. A train moving with a velocity of $20\ \text{ms}^{-1}$ is brought to rest by applying brakes in 5s. Calculate the retardation.

Ans :

Given, $u = 20\ \text{ms}^{-1}$

$v = 0$

$t = 5s$

$a = ?$

Using, $v = u + at$

$0\ \ 20 + a \times 5$

$$a = -\frac{20}{5}$$
$$= -4\ \text{ms}^{-2}$$

Retardation $= 4\ \text{ms}^{-2}$

Negative sign shows it is retardation.

118. A pebble is dropped freely in a well from its top. It takes 20 s for the pebble to reach the water surface in the well. Taking $g = 10\ \text{ms}^{-2}$,and speed of sound $= 330\ \text{ms}^{-1}$,, find :

(i) the depth of water surface, and

(ii) the time when echo is heard after the pebble is dropped.

Ans :

(i) Depth of wall $h = \frac{1}{2}gt^2$

$$h = \frac{1}{2} \times 10 \times (20)^2$$
$$= 5 \times (20 \times 20)$$
$$= 2000\ \text{m}$$

(ii) Time when echo is heard after pebble is dropped

$$\text{T} = 20\ \text{s to reach the water surface} + \frac{\text{distance}}{\text{speed of sound}}$$
$$= 20 + \frac{2000}{330}$$
$$= 20 + 6.1$$
$$= 26.1\ s$$

119. A body is dropped from the top of a tower. It acquires a velocity $20\ ms^{-2}$on reaching the ground. Calculate the height of the tower. (Take $g = 10\ ms^{-2}$)

Ans :

Here $u = 0$

[as the body falls downward]

$g = 10\ ms^{-2}$

$v = 20\ ms^{-1}$

$h = ?$

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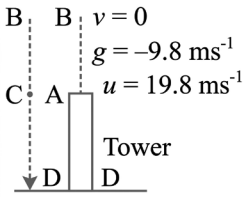


Using $2gh = v^2 - u^2$

$2 \times 10 \times h = (20)^2 - (0)^2$

$h = \frac{400}{20}$

$= 20$

Height of tower $h = 20\,\text{m}$

120. A toy car initially moving with a uniform velocity of 18 km h^{-1} comes to a stop in 2s. Find the retardation of the car in S.I. units.

Ans :

Given, $u = 18\,\text{km h}^{-1}$

$= 18 \times \frac{1000\,\text{m}}{60 \times 60\,\text{s}}$

$= 18 \times \frac{5}{18}\,\text{ms}^{-1}$

$= 5\,\text{ms}^{-1}$

$v = 0$

and $t = 2\,\text{s},$

$a = ?$

Using $v = u + at,$

we get $0 = 5 + a \times 2$

or $2a = -5,$

$a = \frac{-5}{2}\ \text{ms}^{-2}$

or $-2.5\,\text{m}^{-2}$

Retardation $= 2.5\,\text{ms}^{-2}$

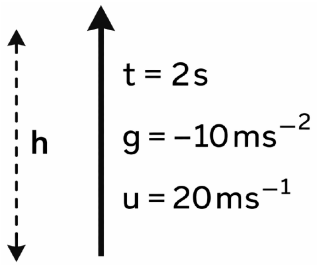
121. A pebble is thrown vertically upwards with a speed of $20\,\text{ms}^{-1}$. How high will it be after 2s? (Take $g = 10\,\text{ms}^{-2}$)

Ans :

Here, body is thrown upward

$g = -10\,\text{ms}^{-2}$

$u = 20\,\text{ms}^{-1}$



$t = 20\,s$

$h = ut + \frac{1}{2}gt^2$

$h = (20 \times 2) + \frac{1}{2}(-10) \times (2 \times 2)$

$= 40 - 20 = 20$

$h = 20\,\text{m}$

122. A body moves from rest with a uniform acceleration and travels 270 m in 3s. Find the velocity of the body at 10 s after the start.

Ans :

Here, $u = 0$

Distance travelled in 3rd second $D_3 = 240\,\text{m}$

$t = 3\,\text{sec}$

(i) using $D(t^{th}) = u + \frac{a}{2}[\,2t + 1\,]$

$270 = 0 + \frac{a}{2}[2 \times 3 - 1]$

$270 = \frac{5}{2}a$

$a = \frac{2 \times 270}{5}$

$= 108\,\text{ms}^{-2}$

Now $v = ?$

$u = 0$

$t = 10\,\text{sec},$

$a = 108\,\text{ms}^{-2}$

$v = u + at$

$v = 0 + (108)(10)$

$v = 1080\,\text{ms}^{-1}$

123. A vehicle is accelerating on a straight road. Its velocity at any instant is 30 km h^{-1}, after 2 s, it is 33.6 km h^{-1} and after further 2 s, it is 37.2 km h^{-1}. Find the acceleration of vehicle in ms^{-2}. Is the acceleration uniform ?

Ans :

Given, $u = 30\ \text{km h}^{-1}$

Velocity after 2 sec $v = 33.6\ \text{km h}^{-1}$

$t = 2s$

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$$a = \frac{v-u}{t}$$
$$= \frac{(33.6-30)}{t} \text{ km}$$
$$= \frac{3.6 \times \frac{5}{18} \text{ms}^{-1}}{2s}$$
$$= 0.5 \text{ ms}^{-2}$$

Now change in velocity in the next

$$2s = 37.2 - 33.6$$
$$= 3.6 \text{ km in 2 sec.}$$
$$a = \frac{3.6 \times \frac{5}{18}}{2}$$
$$= 0.5 \text{ ms}^{-2}$$

as we see velocity changed equally in equal intervals of time
Acceleration is uniform.

124. A body, initially at rest, starts moving with a constant acceleration 2 ms^{-2}. Calculate :
(i) the velocity acquired and
(ii) the distance travelled in 5s.

Ans :

Given, $u = 0$
$a = 2 \text{ ms}^{-2}$
$v = ?$
$s = ?$
$t = 5s$
$v = u + at$

Velocity acquired is given by

$$= v = 0 + 2t$$
$$v = 2 \times 5$$
$$= 10 \text{ms}^{-1}$$

and $2as = v^2 - u^2$
$2 \times 2 \times s = (10)^2 - (0)^2$
$4s = 100 - 0$
$= 100$

Distance travelled

$$= s = \frac{100}{4}$$
$$= 25 \text{ m}$$

125. A bullet initially moving with a velocity 20 ms^{-1} strikes a target and comes to rest after penetrating a distance 10 cm in the target. Calculate the retardation caused by the target.

Ans :

Given, $u = 2 \text{ ms}^{-1}$
$v = 0$
$s = 10 \text{ cm}$
$= \frac{10}{100}$
$= \frac{1}{10} \text{m}$
$a = ?$

Using, $2as = v^2 - u^2$
$2a \times \frac{1}{10} = (0)^2 - (20)^2$
$\frac{a}{5} = 0 - 400$
$= -400$
$a = -400 \times 5$
$= -2000 \text{ ms}^{-2}$

$-$ve sign shows, it is retardation.

Retardation $= 2000 \text{ ms}^{-2}$
u $= 20 \text{ ms}^{-1}$

126. A train is moving with a velocity of 90 km h^{-1}. It is brought to stop by applying the brakes which produce a retardation of 0.5 ms^{-2}. Find :
(i) The velocity after 10 s, and
(ii) The time taken by the train to come to rest.

Ans :

Given, $u = 90 \text{ km h}^{-1}$
$= 90 \times \frac{5}{18}$
$= 25 \text{ ms}^{-1}$
$a = -0.5 \text{ ms}^{-2}$
$= -\frac{1}{2} \text{ ms}^{-2}$
$t = 10s$

(i) Using $v = u + at$
$v = 25 - \frac{1}{2} \times 10$
$= 20$
$v = 20 \text{ ms}^{-1}$

(ii) Using $v = 25 \text{ ms}^{-1}$
$a = -\frac{1}{2} \text{ ms}^{-2}$
$t = ?$
$v = 0$ train comes to rest.

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Using $v = u + at$

$0\ 25 - \frac{1}{2}t,$

$t = 50\,\text{sec}$

127. A car travels a distance 100 m with a constant acceleration and average velocity of 20 m s^{-1}. The final velocity acquired by the car is 25 m s^{-1}. Find: (i) The intial velocity and (ii) acceleration of car

Ans :

(i) Average velocity

$$= \frac{\text{Initial velocity} + \text{final vel.}}{2}$$

$$20 = \frac{(u+25)}{2}$$

$$u + 25 = 40$$

$$u = 40 - 25$$

$$= 15$$

Initial velocity,

$$u = 15\,\text{ms}^{-1}$$

(ii) $\text{Time} = \frac{\text{Distance travelled}}{\text{speed}}$

$$\text{Time} = \frac{100\,\text{m}}{200\,\text{ms}^{-1}}$$

$$= 5s$$

Now, acceleration

$$a = \frac{v-u}{t}$$

$$= \frac{25-15}{5}$$

$$= \frac{10}{5}$$

$$= 2\,\text{ms}^{-2}$$

128. When brakes are applied to a bus, the retardation produced is 25 cm s^{-2} and the bus takes 20 s to stop. Calculate :

(i) the initial velocity of bus, and

(ii) the distance travelled by bus during this time.

Ans :

Given, $v = 0$

$$a = -25\,\text{cm s}^{-2}$$

$$= -\frac{25}{100}\,\text{ms}^{-2}$$

$$= -\frac{1}{4}\,\text{ms}^{-2}$$

$u = ?$

t 20s

(i) Using $v = u + at$

$$0 = u - \frac{1}{4} \times 20$$

$$0 = u - 5$$

$$u = 5\,\text{ms}^{-1}$$

(ii) Distance travelled in 20 sec

$u = 5\,\text{ms}^{-1}$

t 20 sec.

$$a = -\frac{1}{4}\,\text{ms}^{-2}$$

Using $s = ut + \frac{1}{2}at^2$

$$s = (5 \times 20) - \frac{1}{2} \times \frac{1}{4} \times 20 \times 20$$

$$= 100 - 50$$

$$s = 50\,\text{m}$$

129. A body moving with a constant acceleration travels the distance 3 m and 8 m respectively in 1 s and 2 s.

Calculate :

(i) the initial velocity and

(ii) the acceleration of body.

Ans :

Given,

Distance travelled in first second, $D_1 = 3\text{m}$

Distance travelled in 2nd second, $D_2 = 8\text{m}$

So, $D_1 = u + \frac{a}{2}(2t-1)$

$$3 = u + \frac{a}{2}(2 \times 1 - 1)$$

$$3 = u + \frac{a}{2} \quad \text{...(i)}$$

Similarly, $D_2 = u + \frac{a}{2}(2t-1)$

$$8 = u + \frac{a}{2}(2 \times 2 - 1)$$

$$8 = u + \frac{3a}{2} \quad \text{...(ii)}$$

by subtracting eqn (i) and (ii) we get, $5 = \frac{2a}{2}$,

Thus $a = 5\,\text{ms}^{-2}$

Putting $a = 5$ in eqn (i), we get

$$3 = u + \frac{5}{2}$$

$$3 = \frac{2u+5}{2}$$

$$6 = 2u + 5$$

$$\frac{6-5}{2} = u$$

$$\frac{1}{2} = u$$

$$u = 0.5\,\text{ms}^{-1}$$

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130. A car travels with a uniform velocity of $25\,\text{ms}^{-1}$ for 5 s.The brakes are then applied and the car is uniformly retarded and comes to rest in further 10 s.
Find :
(i) The distance which the car travels before the brakes are applied,
(ii) The retardation, and
(iii) The distance travelled by the car after applying the brakes.

Ans :
(i) As car travels with a uniform velocity
Distance = Velocity × Time
Covered 25×5 =125 m
Initial Velocity after covering 125 m will still be
$25\,\text{ms}^{-1}$
Velocity after 5 sec.

(ii) $u = 25\,\text{ms}^{-1}$
$v = 0$
$t = 10\,\text{sec},$
$a = ?$
$v = u + at$
$0 = 25 + a \times 10$
$10a = -25$
$a = -2.5\,\text{ms}^{-2}$ i.e. retardation
$= 2.5\,\text{ms}^{-2}$

(iii) Now $u = 25\,\text{ms}^{-1}$
$a = -2.5\,\text{ms}^{-2}$
$t = 10\,\text{sec},$
$s = ?$

Using $2as = v^2 - u^2$
$2 \times \left(\frac{-5}{2}\right)s = (0)^2 - (25)^2$
$-5s = 0 - 625$

Distance covered $= s = 125\,\text{m}$

Distance travelled by the car after the breaks are applied.

131. A space craft flying in a straight course at $75\,\text{km s}^{-1}$fires its rocket motors for 6.0 s. At the end of this time its speed is $120\,\text{km s}^{-1}$ in the same direction.
Find :
(i) The space craft's average acceleration while the motors were firing,
(ii) The distance travelled by the space craft in the first 10 s after the rocket motors were started, the motors having been in action for only 6.0 s.

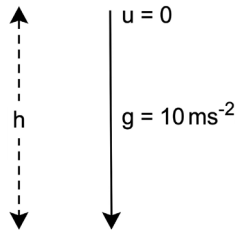
Ans :
When space craft fires its rocket motors, then
$u = 75\,\text{km s}^{-1},$
$v = 120\,\text{km s}^{-1},$
$t = 6.0s, a = ?$

Using $v = u + at$
$120 = 75 + a \times 6$
$a = \frac{45}{6} = 7.5\,\text{km s}^{-2},$
$t = 6\,\text{sec},$
$v = 120\,\text{km s}^{-1}$

Distance covered in 10 sec after the motors were velocity $120\,\text{km s}^{-1}$
Distance covered
$= s = ut + \frac{1}{2}at^2 + (v \times t)]$
$= \left[75 \times 6 + \frac{1}{2} \times \frac{15}{2} \times 36\right] + (120 \times 4)$
$(450 + 135) + 480$
$s = 1065\,\text{km}.$

132. A ball is thrown vertically upwards. It returns 6 s later. Calculate:
(i) The greatest height reached by the ball and
(ii) The initial velocity of the ball. (Take $g = 10\,\text{ms}^{-2}$)

Ans :
Since time of ascent is always equal to the time of descent.
Time taken for downward motion.
$t = \frac{6}{2} = 3\,\text{sec}.$



$t = 3s$
$h = ?$
$g = 10\,\text{ms}^{-2}$
$h = 0$

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(i) $h = \frac{1}{2} gt^2$

$= \frac{1}{2} \times 10 \times 3 \times 3 = 45$

Greatest height reached $h = 45$

(ii) For upward motion at maximum height reached

$v = 0$

$0 = u - 10 \times 3$

$u = 30\ \text{ms}^{-1}$

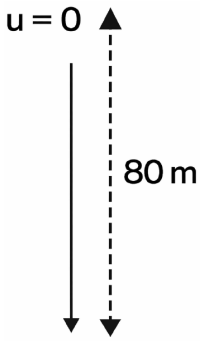
133. How long will a stone take to fall to the ground from the top of a building 80m high and what will be the velocity of the stone on reaching the ground?
(Take $g = 10\ \text{ms}^{-2}$)

Ans :
As stone falls down
Initial velocity

$u = 0,$

$u = 80\ m,$

$g = 10\ \text{ms}^{-2}$



Using $s = \frac{1}{2} gt^2$

$h = 80$

$= \frac{1}{2} \times 10 gt^2$

$t^2 = 16$

$t = \sqrt{16} = 4s$

(ii) To final velocity v on reaching the ground

$v^2 - u^2 = 2gh$

$v^2 - (0)^2 = 2 \times 10 \times 80$

$= 1600$

$v = 40\ \text{ms}^{-1}$

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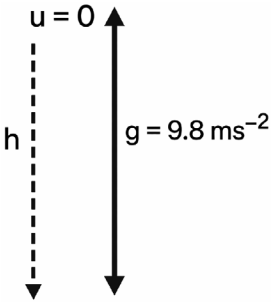
134. A body falls from the top of a building and reaches the ground 2.5 s later. How high is the building?
(Take $g = 9.8\ \text{ms}^{-2}$)

Ans :
Given,

$u = 0$

$g = 9.8\ \text{ms}^{-2}$



$t = 2.5s,$

Using $h = \frac{1}{2} gt^2$

$h = \frac{1}{2} \times 9.8 \times 2.5 \times 2.5$

$= 30.625\ \text{m}$

Height of the building $h = 30.625\ \text{m}$

135. A ball is thrown vertically upwards with an initial velocity of $49\ \text{ms}^{-1}$
Calculate :
(i) The maximum height attained,
(ii) The time taken by it before it reaches the ground again.

Ans :
For a body thrown vertically upward

$u = 0,$

$g = -9.5\ \text{ms}^{-2},$

$u = 49\ \text{ms}^{-1},$

$t = ?$

Using, $v = u + gt$

$0 = 49 - 9.8\, t$

$t = 5s$

It will also take $t = 5s$ to come back.

(i) Total time taken $= 5 + 5 = 10s$

(ii) and while falling down

$u = 0$

$t = 5s$

$$g = 9.8\,\text{ms}^{-2}$$

$$h = ut + \frac{1}{2}gt^2$$

$$h = 0 + \frac{1}{2} \times 9.8 \times 5 \times 5$$

$$h = 122.5\,\text{m}$$

Maximum height attained $h = 122.5\,\text{m}$

136. A ball is thrown vertically upwards from the top of a tower with and initial velocity of 19.6 ms^{-1}. The ball reaches the ground after 5 s. Calculate :
(i) The height of the tower,
(ii) The velocity of ball on reaching the ground.
Take g = 9.8 ms^{-2}.

Ans :
For ball in going from A to B

$$v = u + gt$$
$$0 = 19.6 - 9.8$$
$$t = 9.8$$
$$t = 19.6$$
$$t = \frac{19.6}{9.8}$$
$$= 2\,\text{sec}.$$

Time of Ascent = time of descant
T from B to C is also 2 sec.
Time from C to D i.e. Top of tower to ground

$$= 5 - 4 = 1\,\text{sec}.$$

Distance BC $= h_1 = ut + \frac{1}{2}gt^2$

$$= 0 + \frac{1}{2} \times 9.8(2)^2$$
$$= \frac{1}{2} \times 9.8 \times 4$$
$$= 19.6\,\text{m}$$

(i) Height of tower

$$= BD - BC$$
$$ut + \frac{1}{2}gt^2 - 19.6$$
$$= 0 + \frac{1}{2} \times 9.8(3)^2 - 19.6$$
$$= 44.1 - 19.6$$
$$= 24.5\,\text{m}$$

(ii) Vel. of ball on reaching the ground,

$$v = u + gt$$
$$= 0 + 9.8 \times 3$$
$$= 29.4\,\text{ms}^{-1}.$$

137. A car is moving in a straight line with speed 18 km h^{-1}. It is stopped in 5 s by applying the brakes. Find : (i) the speed of car in ms^{-1}, (ii) the retardation and (iii) the speed of car after 2 s of applying the brakes.

Ans :
(i) Speed 18 km h^{-1}

Speed in ms^{-1} $= \frac{18 \times 1000\,\text{m}}{60 \times 60\,\text{s}}$

$$= \frac{18000\,\text{m}}{3600\,\text{s}}$$
$$= 5\,\text{ms}^{-1}$$

(ii) $u = 0,$
$v = 5\,\text{ms}^{-1},$
$t = 5s,$
$a = ?$
$v = u + at$
$5 = 0 + a \times 5$
$5a = 5$
$a = \frac{5}{5}$
$= 1\,\text{ms}^{-1}$

Retardation $= 1\,\text{ms}^{-1}$

(iii) $v = 5\,\text{ms}^{-1},$
$t = 2\,\text{sec},$
$a = 1\,\text{ms}^{-1},$
$u = ?$
$u = v - at$
$u = 5 - 1 \times 2$
$= 5 - 2$
$= 3\,\text{ms}^{-1}$

138. A car travels first 30 km with a uniform speed of 60 km h^{-1} and the next 30 km with a uniform speed of 40 km h^{-1}. Calculate:
(i) the total time of journey,
(ii) the average speed of the car.

Ans :
(i) Time $= \frac{\text{distance}}{\text{speed}}$

For the first 30 km, $t_1 = \frac{30\,\text{km}}{60\,\text{km h}^{-1}}$

$$= 0.5\,\text{h}$$

For the second 30 km,

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$$t_2 = \frac{30\text{ km}}{40\text{ km h}^{-1}}$$

$$= 0.75\text{ h}$$

Total time of journey $= t_1 + t_2$

$$= 0.5\text{ h} + 0.75\text{ h}$$

$$= 1.25\text{ h}$$

$$= 1.25 \times 60\text{ minutes}$$

$$= 75\text{ minutes}$$

(ii) Average speed of the car

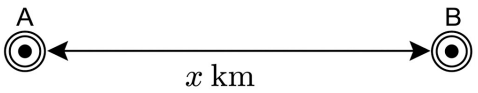
$$= \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$= \frac{60\,km}{1.25\,h}$$

$$= 48\text{ km h}^{-1}$$

139. A train travels with a speed of 60 km h^{-1} from station A to station B and then returns back with a speed 80 km h^{-1} from station B to station A. Find: (i) the average speed, and (ii) the average velocity of train.

Ans :



Let distance between two stations be $= x$ km

For train from A to B distance $= x$ km

$$\text{Velocity} = 60\text{ km h}^{-1}$$

$$\text{Time } T_1 = \frac{\text{distance}}{\text{vel.}} = \frac{x}{60}\text{ hrs.}$$

For train from B to A distance $= x$ km

$$\text{Velocity} = 80\text{ km h}^{-1}$$

$$\text{Time } T_2 = \frac{\text{dist.}}{\text{vel}} = \frac{x}{80}\text{ hrs.}$$

Total time for train from A to B and back to

$$A = T_1 + T_2$$

$$= \frac{x}{60} + \frac{x}{80}$$

$$= \frac{7x}{240}\text{ hrs.}$$

Total distance covered $= x + x = 2x$ km

(i) $$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

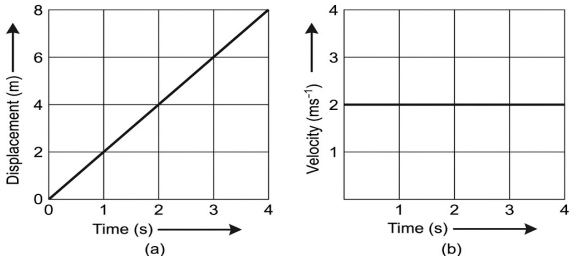
$$= \frac{2x}{\frac{7x}{240}} = \frac{2x \times 240}{7x}$$

$$= 68.57\text{ km h}^{-1}$$

(ii) Average velocity of train = zero

As train returns to A, displacement is zero.

140. Figure (a) shows the displacement - time graph for the motion of a body. Use it to calculate the velocity of body at $t = 1$ s, 2 s and 3 s, then draw the velocity - time graph in Fig. (b) for it.



Ans :

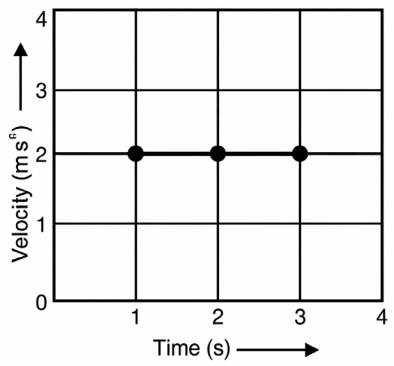
From the fig. (a) it is clear that velocity after 1,2,3 and 4 sec is

$$\text{Velocity} = \frac{\text{distance}}{\text{time}}$$

$$= \frac{2}{1} = \frac{4}{2} = \frac{6}{3} = \frac{8}{4}$$

$$\text{Velocity} = 2\text{ ms}^{-1}$$

i.e. velocity remains constant which is a straight line parallel to time axis.



141. A car moving on a straight path covers a distance of 1 km due east in 100 s. What is (i) the speed and (ii) the velocity, of car?

Ans :

Distance AB $= 1$ km $= 1000$ m,

$$t = 1000\text{ s}$$

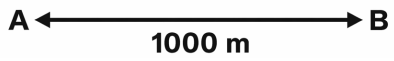
$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$= \frac{1000\text{ m}}{100\text{ s}}$$

$$= 10\text{ ms}^{-1}$$

Displacement from A to B

$$= 1\text{ km} = 1000\text{ m}$$



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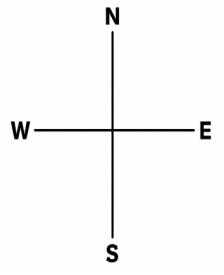
$t = 100$ sec



$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

$$= \frac{1000\text{ m}}{100\text{ s}}$$

$$= 10\text{ ms}^{-1}$$

Speed $= 10\text{ ms}^{-1}$,

Velocity $= 10\text{ ms}^{-1}$ due east.

142. Following table gives the displacement of a car at different instants of time. (a) Draw the displacement - time sketch and find the average velocity of car. (b) What will be the displacement of car in 2.5 s and 4.5 s?

Time (s)	0	1	2	3	4
Displacement (m)	0	5	10	15	20

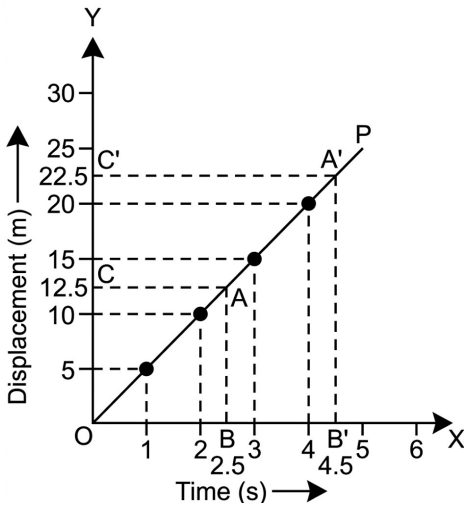
Ans :

(a) Graph showing change of displacement with time.

$$\text{Average velocity} = \frac{\text{total distance covered}}{\text{total time taken}}$$

$$\text{Average velocity} = \frac{20\text{ m}}{4\text{ s}}$$

$$= 5\text{ ms}^{-1}$$



(b) From graph on x - axis mark B at 2.5 s and draw AB || y - axis to meet straight line OP at A and draw AC || x - axis to meet y - axis at C. Note the reading at C it is found to be 12.5 m.

Displacement of car in 2.5 s is 12.5 m.

Similarly, B′at 4.5 s displacement of car is reading at C′= 22.5 m.

143. A body is moving in a straight line and its displacement at various instants of time is given in the following table :

Time (in s)	0	1	2	3	4	5	6	7
Displacement (m)	2	6	12	12	12	18	22	24

Plot displacement - time graph and calculate :

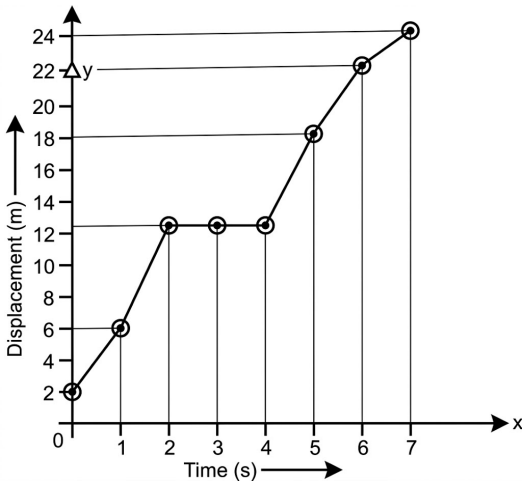
(i) Total distance travelled in interval 1s to 5s.

(ii) Average velocity in time interval 1s to 5s.

Ans :

(i) Distance travelled in 1s to 5s from the table is $18 - 6 = 12$ m

(ii) Average velocity in time interval 1s to 5s i.e. $(5 - 1) = 4$s is $= \frac{\text{Displacement}}{\text{time}}$



$$\text{Average velocity} = \frac{12\text{m}}{4\text{s}} = 3\text{ ms}^{-1}$$

144. From the displacement - time graph of a cyclist, given in figure, find :

(i) The average velocity in the first 4 s,

(ii) The displacement from the initial position at the end of 10 s,

(iii) The time after which he reaches the starting point.

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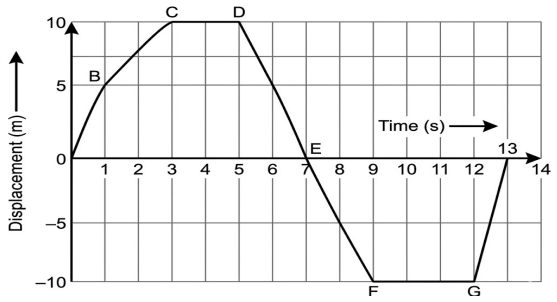


Ans :

To find displacement we look at y - axis and to find time at x - axis.

(i) Displacement in first 4 s from y - axis = 10 m

$$t = 4 \text{ s}$$

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time taken}}$$

$$= \frac{10}{4} = 20.5 \text{ ms}^{-1}$$

(ii) Displacement from 0 s to 10 s from y - axis corresponding to 10 s on x - axis is -10 m. Displacement can be negative.

(iii) Looking at graph corresponding to zero displacement he will reach the starting point (zero displacement) at 7 s and 13 s.

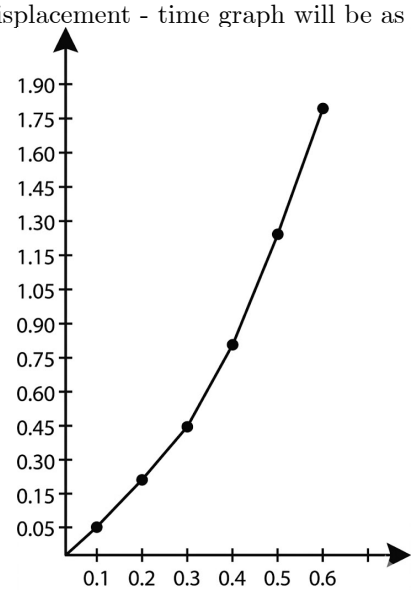
145. A body at rest is made to fall from the top of tower. Its displacement at different instants ig given in the following table:

Time (in s)	0.1	0.2	0.3	0.4	0.5	0.6
Displacement (in m)	0.05	0.20	0.45	0.80	1.25	1.80

Draw a displacement - time graph and state whether the motion is uniform or non - uniform?

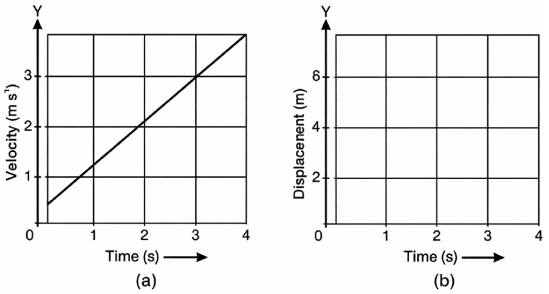
Ans :

The displacement - time graph will be as :



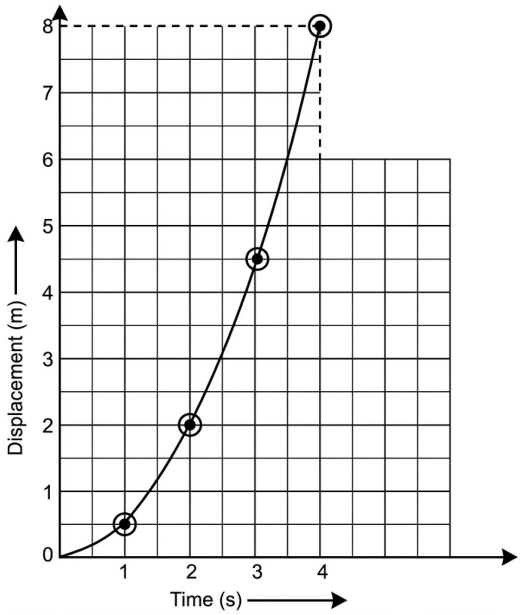
Since the graph is a curve, so the motion is with non - uniform velocity.

146. Figure (a) shows the velocity - time graph for the motion of a body. Use it to find the displacement of the body at t = 1s, 2s, 3s and 4s, then draw, the displacement - time graph for it on Fig. (b).



Ans :

Displacement at various times corresponding to velocity - time graph can be calculated by the area under velocity - time graph i.e. after 1,2,3 and 4 sec = .5, 2, 4.5 and 8 m respectively.



147. A train takes 2 h to reach station B from station A, and then 3h to return back from station B to station A. The distance between the two stations is 200 km. Find :

(i) The average speed,

(ii) The average velocity of the train.

Ans :

Total, t = 2 hrs + 3 hrs = 5 hrs

Distance between two stations = 200 km

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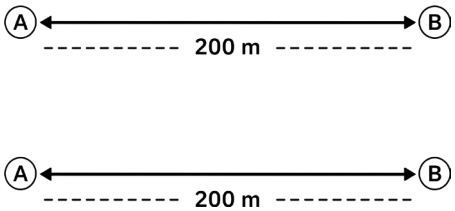


Total distance for going and coming back

$$= AB + BA$$

$$= 200 + 200$$

$$= 400 \text{ km}$$

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time taken}}$$

(i) $$\text{Average speed} = \frac{400 \text{ km}}{5 \text{ hrs}} = 80 \text{ km h}^{-1}$$

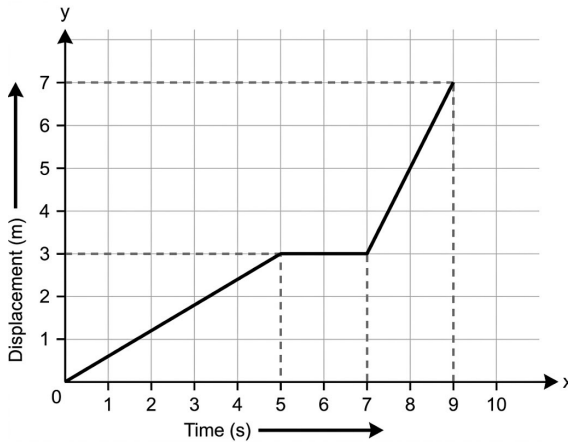
(ii) $$\text{Average velocity} = \frac{\text{displacement}}{\text{total time taken}}$$

$$\text{Average velocity} = \frac{0}{5} = 0 \text{ (zero)}.$$

148. Figure shows the displacement of a body at different times.

(a) Calculate the velocity of the body as it moves for time interval (i) 0 to 5 s, (ii) 5 s to 7 s and (iii) 7 s to 9 s.

(b) Calculate the average velocity during the time interval 5 s to 9 s.



Ans :

(a) As we know that ,

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}}$$

(i) Displacement during 0 to 5 s = 3 m

$$\text{Time taken} = 5 - 0 = 5 \text{ s}$$

$$\text{Velocity} = \frac{3 \text{ m}}{5 \text{ s}} = 0.6 \text{ ms}^{-1}$$

(ii) Displacement during 5 s to 7 s = 0 m
Straight line || to x - axis shown by graph

Duration $t = 7 - 5 = 2 \text{ s}$

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}}$$

$$= \frac{0 \text{ m}}{2 \text{ s}} = 0 \text{ ms}^{-1}$$

(iii) Displacement during 7 s to 9 s = (7 – 3) = 4 m

Duration $t = 9 - 7 = 2 \text{ s}$

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}}$$

$$= \frac{4 \text{ m}}{2 \text{ s}} = 2 \text{ ms}^{-1}$$

(b) Average velocity during 5 s to 9 s

$$= \frac{\text{displacement}}{\text{time taken}}$$

$$= \frac{(7-3) \text{ m}}{(9-5) \text{ s}}$$

$$= \frac{4}{4} = 1 \text{ ms}^{-1}$$

149. Figure shows the velocity - time graph of a particle moving in a straight line.

Answer the following.

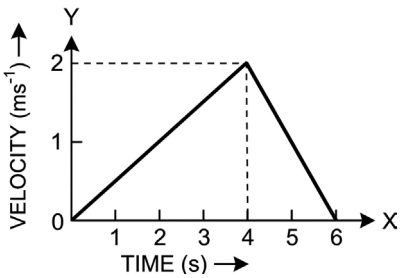
(i) State the nature of motion of particle.

(ii) Find the displacement of particle of $t = 6$ s.

(iii) Does the particle change its direction of motion?

(iv) Compare the distance travelled by the particle from 0 to 4 s to 6 s?

(v) Find the acceleration from 0 to 4 s and retardation from 4 s to 6 s.



Ans :

(i) It is uniformly accelerated from 0 to 4 s and then uniformly retarded from 4 s to 6 s.

(ii) Displacement = area of

$$\Delta = \frac{1}{2} \text{ base} \times \text{height}$$

$$= \frac{1}{2} \times 6 \times 2 = 6 \text{ m}.$$

(iii) No.

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(iv) The distance travelled by the particle from 0 s to 4 s not same as from 4 s to 6 s, it differs by 2 : 1.

(v) Acceleration from 0 to 4 s

$$= \frac{\text{Increase in velocity}}{\text{Time taken}}$$

$$= \frac{(2-0)\,\text{ms}^{-1}}{(4-0)\,s}$$

$$= \frac{2}{4}\text{ms}^{-2} = 0.5\,\text{ms}^{-2}$$

From 4 s to 6s

$$= \frac{\text{Decrease in velocity}}{\text{Time taken}}$$

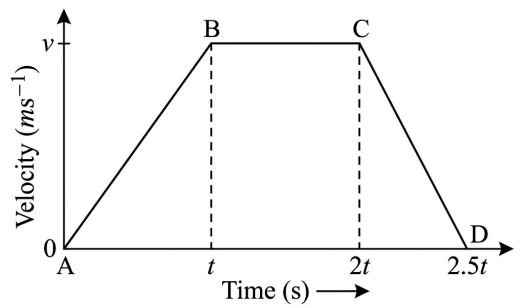
$$= \frac{(0-2)\,\text{ms}^{-1}}{(6-4)\,s}$$

$$= \frac{-2}{2}\text{ms}^{-2}$$

$$= -1\,\text{ms}^{-2}$$

$$\text{Retardation} = 1\,\text{ms}^{-2}$$

150. Figure given below shows a velocity - time graph for a car starting from rest. The graph has three parts AB, BC and CD.



(i) State how is the distance travelled i any part is determined from this graph.

(ii) Compare the distance travelled in part BC with the distance travelled in part AB.

(iii) Which part of graph shows motion with uniform (a) velocity (b) acceleration (c) retardation ?

(iv) Is the magnitude of acceleration higher or lower than that of retardation ? Give a reason.
(b) Compare the magnitude of acceleration and retardation.

Ans :

(i) The area under that part above the x - axis gives distance travelled.

(ii) $\dfrac{\text{Distance travelled in part BC}}{\text{Distance travelled in part AB}}$

$$= \frac{v_0 \times t}{\frac{1}{2} \times t \times v_0} = \frac{2}{1} = 2:1$$

(iii) (a) Part BC shows velocity,
(b) Part AB shows acceleration
(c) art CD shows retardation.

(iv) (a) Acceleration = slope of

$$\text{AB} = \frac{Bt}{At} = \frac{v_0}{t} \quad \ldots(\text{i})$$

Retardation = slope of

$$\text{CD} = \frac{v_0}{\frac{1}{2}t} = 2\frac{v_0}{t} \quad \ldots(\text{ii})$$

Magnitude of retardation is twice the magnitude of acceleration
Magnitude of acceleration is lower.

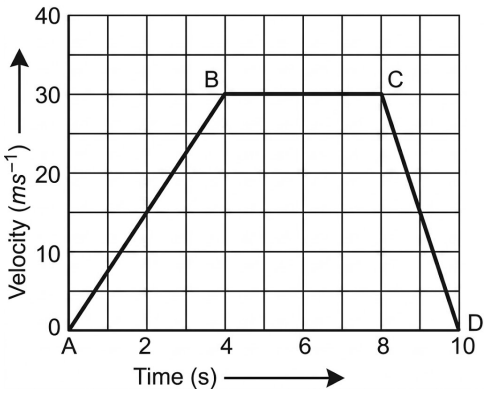
(b) $\dfrac{v_0}{t} = 2\dfrac{v_0}{t} = 1:2$

151. The velocity - time graph of a moving body is given below in figure, find:

(i) The acceleration in parts AB, BC and CD.

(ii) Displacement in each part AB, BC, CD and

(iii) Total displacement.



Ans :

(i) Acceleration in the part AB = slope of

$$\text{AB} = \frac{30}{4} = 7.5\,\text{ms}^{-2}$$

Acceleration in the part BC $= 0\,\text{ms}^{-2}$
Velocity remains constant in this part.
Acceleration in the part CD = slope of

$$\text{CD} = \frac{30}{2} = -15\,\text{ms}^{-2}$$

Velocity is decreasing and acceleration is negative.

(ii) Displacement in the area under each part.
Displacement in part AB

$$= \frac{1}{2}(4-0)\,(30)$$

$$= \frac{1}{2} \times 4 \times 30$$

$$= 60\,\text{m}$$

Displacement in part AB

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$$= \frac{1}{2}(4-0)(30)$$

$$= \frac{1}{2} \times 4 \times 30$$

$$= 60 \text{ m}$$

Displacement in part BC

$$= (8-4) \times (30-0)$$

$$= 4 \times 30 = 120\, m$$

Displacement in part CD

$$= \frac{1}{2}(10-8)(30)$$

$$= 30\, m$$

(iii) Total displacement

$$= 60 + 120 + 30$$

$$= 210\, m$$

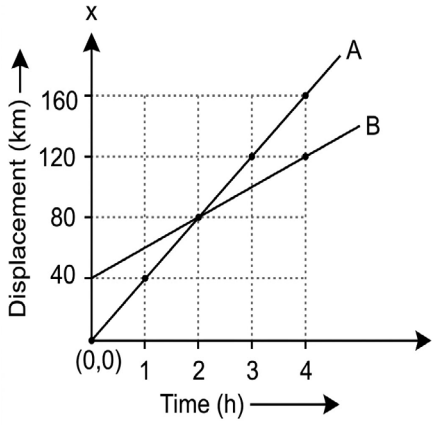
152. Figure below represents the displacement - time sketch of motion of two cars A and B.
Find

(i) The distance by which the car B was initially ahead of car A.

(ii) The velocitites of car A and car B.

(iii) The time in which the car A catches the car B.

(iv) The distance from start when the car A will catch the car B.



Ans :

(i) Car B was initially 40 km (from y - axis) ahead of car A (0 km = at rest)

(ii) Distance covered by car

$$A = 80 - 0 = 80 \text{ km}$$

and distance covered by

$$B = (80 - 40) = 40 \text{ km}$$

Time taken by car

$$A = (2-0) = 2 \text{ hrs}$$

Time taken by car

$$B = (2-0) = 2 \text{ hrs}$$

Velocity of car

$$A = \frac{\text{displacement}}{\text{time}}$$

$$= \frac{80}{2} = 40 \text{ kmh}^{-1}$$

and velocity of car

$$B = \frac{40}{2} = 20 \text{ kmh}^{-1}$$

(iii) Car A will catch the car B after 2 hrs shown by the intersection of straight lines

$$\text{i.e. } \frac{\text{Velocity of car A}}{\text{Velocity of car B}} = \frac{40}{20}$$

$$= 2 \text{ hr.}$$

(iv) Distance from start when car A will catch car B = 80 km, as shown by point of intersection.

153. A train starts from rest and accelerates uniformly at a rate of 2 ms^{-2} for 10 s. It then maintains a constant speed for 200 s. The brakes are then applied and the train is uniformly retarded and comes to rest in 50 s.
Find :

(i) The maximum velocity reached,

(ii) The retardation in the last 50 s,

(iii) The total distance travelled and

(iv) The average velocity of the train.

Ans :

Given, for the first 10 secs.

$$u = 0,$$

$$v = ?$$

$$a = 2 \text{ms}^{-2}$$

$$t = 10 \text{ sec},$$

$$s_1 = ?$$

(i) $$v = u + at$$

$$v = 0 + 2 \times 10$$

$$v = 20 \text{ ms}^{-1} \quad \text{...(i)}$$

$$2as_1 = v^2 - u^2$$

$$2 \times 2s_1 = (20)^2 - (0)^2$$

$$4s_1 = \frac{400}{4}$$

$$= 100 \text{ m} \quad \text{...(ii)}$$

Distance in

$$200 \text{ s} = vt$$

$$s_2 = 200 \times 20 = 4000 \text{ m} \quad \text{...(iii)}$$

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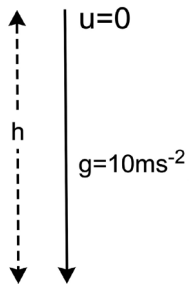
(ii) Retardation in last 50 s



$$v = u + at$$
$$0 = 20 + a \times 50$$
$$50a = -20$$
$$a = -\frac{20}{50}$$
$$= -0.4 \text{ ms}^{-2}$$

and distance covered in 50 sec is given by

$$2as = v^2 - u^2$$
$$2 \times \left(\frac{-2}{5}\right)s = 0^2 - (20)^2$$
$$\frac{-4}{5}s = -400$$
$$s = 400 \times \frac{5}{4}$$
$$= 500$$
$$s_3 = 500 \text{ m}$$

Total distance covered $= s_1 + s_2 + s_3$

$$= 100 + 4000 + 500$$
$$= 4600$$
$$s = 4600 \text{ m}$$

(iv)Average velocity

$$= \frac{\text{total distance covered}}{\text{Total time taken}}$$
$$= \frac{4600 \text{ m}}{(10 + 200 + 50)\text{s}}$$
$$= \frac{4600}{260}$$
$$= 17.69 \ = 17.69 \text{ ms}^{-1}$$

CASE BASED QUESTIONS

154. Karthik travelled to a neighbouring town for a science exhibition. He rode his bicycle on a straight, undeviating road for the entire trip. For the first half of his journey, he covered a distance of 12 kilometres in exactly 1 hour. Because of heavy rain, he had to slow down significantly during the second half of his journey. He covered the remaining 12 kilometres in 2 hours to reach his final destination safely. His science teacher later asked him to analyse his journey mathematically using the concepts learned in class.

(a) Calculate the average speed of Karthik for the entire journey.

(b) Calculate his average velocity for the journey, and state one difference between speed and velocity.

Ans :

(a) $$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$
$$= \frac{(12 + 12)}{(1 + 12)}$$
$$= 8 \text{ km h}^{-1}$$

(b) $$= \frac{\text{Total displacement}}{\text{Total time}}$$
$$= \frac{24}{3}$$
$$= 8 \text{ km h}^{-1}$$

Speed is a scalar quantity that is always positive, while velocity is a vector quantity that can be positive or negative depending on direction.

155. Vikram was observing traffic from his balcony overlooking a straight, level highway. He noticed a car travelling at a high initial velocity of 30 ms^{-1}. Suddenly, a stray dog ran across the road, and the driver immediately applied the brakes to avoid an accident. The car slowed down at a constant rate and came to a complete halt in exactly 5 seconds. Vikram quickly noted down the time using his digital stopwatch. He later used his physics textbook to calculate the braking capabilities of the car.

(a) Calculate the uniform retardation of the car.

(b) Calculate the distance travelled by the car after the brakes were applied.

Ans :

(a) $$a = \frac{(v - u)}{t}$$
$$a = \frac{(0 - 30)}{5}$$
$$\text{a} = -6 \text{ m s}^{-2} \qquad (\text{Retardation is } 6 \text{ m s}^{-2})$$

(b) $$\text{S} = \text{ut} + \frac{1}{2}\text{at}^2$$

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$$S = 30 \times 5 + 0.5 \times (-6) \times (5)^2$$

$$S = 75\text{m}$$

156. Rahul was helping his family move to a new apartment. He first lifted a heavy box of mass 15 kg and carefully placed it on top of another box of mass 25 kg. He then pushed a heavy furniture piece, applying a steady force to move it 4 metres strictly towards the east direction. While sitting on a chair inside the moving transport truck, he observed the trees outside appearing to move backwards rapidly. His sister noted that his position relative to the truck remained unchanged during the entire journey. They discussed how different physical quantities have different rules for combining them.

(a) Calculate the total mass of the two boxes and state whether mass is a scalar or vector quantity.

(b) Name the three parameters required to express the displacement of the furniture completely.

(c) Give one reason why Rahul is considered to be at rest with respect to the truck but in motion with respect to the trees outside.

Ans :

(a) $\text{Mass} = m_1 + m_2$

$= 15\,\text{kg} + 25\,\text{kg} = 40\text{kg}$

Mass is a scalar quantity because it is completely expressed only by its magnitude and requires no direction.

(b) The three parameters required are the unit in which the quantity is measured, the numerical value of the measured quantity, and the specific direction.

(c) Rahul is at rest relative to the truck because his position does not change with respect to his immediate surroundings, but in motion relative to trees because his position continuously changes compared to them.

157. Ananya was practising for her athletics competition on a large rectangular field. She started running from one corner of the field, designated as point P. She ran straight along the length of the field covering 40 metres to reach point Q. Immediately after, she turned at a right angle and ran along the width of the field covering 30 metres to reach point R. Her coach recorded her total time for this run as 10 seconds. She then stopped at point R to catch her breath before jogging back to the starting point.

(a) Calculate the total distance travelled by Ananya from point P to point R.

(b) Calculate the magnitude of displacement of Ananya from point P to point R.

(c) State whether the displacement can be zero if Ananya returns to point P, giving one reason.

Ans :

(a) $\text{Distance} = \text{PQ} + \text{QR}$

$= 40\,\text{m} + 30\,\text{m}$

$= 70\text{m}$

(b) $\text{Displacement} = \sqrt{\text{PQ}^2 + \text{QR}^2}$

$= \sqrt{40^2 + 30^2} = 50\text{m}$

(c) Yes, the displacement can be exactly zero. If a body returns to its initial point after travelling a certain distance, the shortest distance between the initial and final positions becomes exactly zero.

158. Sunita was conducting an outdoor experiment on gravity near her school playground. She held a dense rubber ball in her hand and threw it vertically upwards with a strong push. The ball left her hand with an initial velocity of 20 m s^{-1}. She watched carefully as the ball travelled upward, slowed down, reached its highest position, and then fell back down to her hand. She assumed the acceleration due to gravity to be exactly 10 m s^{-2} for her calculations and ignored any air resistance.

(a) State the velocity of the ball when it reaches its maximum height.

(b) Calculate the time taken by the ball to reach the maximum height.

(c) Calculate the maximum height reached by the ball.

(d) State the total displacement of the ball when it returns to Sunita's hand.

Ans :

(a) The velocity of the ball when it reaches its maximum upward height is exactly zero metre per second because it momentarily stops before falling.

(b) $t = \dfrac{(u - v)}{g}$

$t = \dfrac{(20 - 0)}{10}$

$t = 2s$

(c) $h = \dfrac{u^2}{2g}$

$\text{h} = \dfrac{(20 \times 20)}{(2 \times 10)}$

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$$h = 20m$$

(d) The total displacement of the ball when it returns to Sunita's hand is exactly zero because the final position is the identical starting point.

159. Rajesh was travelling in a bus with his father on a crowded city road. He noticed that the bus covered 50 metres in the first 10 seconds, but only 20 metres in the next 10 seconds due to heavy traffic. Later, when the road cleared, the driver maintained a steady pace, covering exactly 100 metres every 5 seconds. Rajesh continuously watched the speedometer on the dashboard, which showed reading values fluctuating constantly. He decided to classify the different phases of the journey based on the types of motion he studied.

(a) Name the type of motion exhibited by the bus during the crowded traffic phase.

(b) Name the type of motion exhibited by the bus when the road cleared.

(c) Name the physical quantity measured by the speedometer of the bus.

(d) State the SI unit of velocity.

Ans :

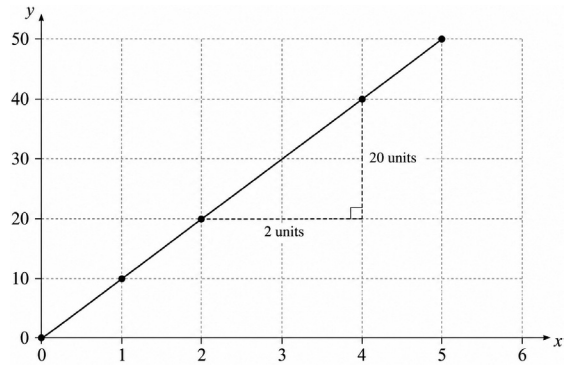
(a) The bus exhibits non-uniform motion because it travels unequal distances in equal intervals of time during the heavily crowded traffic phase.

(b) The bus exhibits uniform motion because it travels exactly equal distances in equal intervals of time once the road clears entirely.

(c) The speedometer constantly measures the exact instantaneous speed of the moving vehicle at any particular given instant of time.

(d) The SI unit of velocity is metre per second, which is mathematically represented as ms^{-1}.

160. Meera performed a motion-tracking experiment using a motorised toy car on a straight track. She recorded its position at regular intervals and plotted the data on a graph. The recorded motion showed a consistent pattern throughout the 5-second interval. She references the graph below for her specific analysis.



(a) Calculate the velocity of the toy car at the 4-second mark using the graph.

(b) Identify the position of the car at the 3-second mark.

(c) Name the type of motion represented by the straight line inclined to the horizontal axis.

Ans :

(a) $\text{Velocity} = \dfrac{(\text{Final position} - \text{Initial position})}{(\text{Fine time} - \text{Initial time})}$

$$= \frac{(40-0)}{(4-0)} = 10ms^{-1}$$

(b) By carefully observing the plotted straight line on the graph, the exact position of the toy car at the 3-second mark is identified as 30 metres.

(c) The straight diagonal line inclined to the horizontal time axis on the graph represents an object moving with a strictly uniform and constant velocity.

161. Rohan was studying the performance of a remote-controlled aeroplane on a smooth runway. He noted its increasing speed over a specific time interval and plotted the data. The aeroplane started from rest and sped up steadily. He references the graph below to mathematically find the distance covered.

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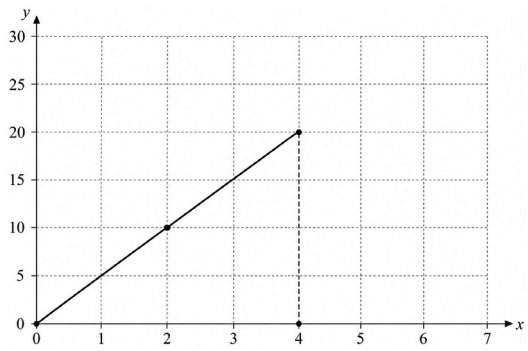


(a) Calculate the acceleration of the aeroplane from the graph.

(b) Calculate the displacement of the aeroplane in the first 4 seconds.
(c) State what the area enclosed between the plotted line and the horizontal axis represents.

Ans :

(a) $\text{Acceleration} = \dfrac{(\text{Change invertical value})}{(\text{Change in horizontal value})}$

$= \dfrac{(20-0)}{(4-0)} = 5\ \text{ms}^{-2}$

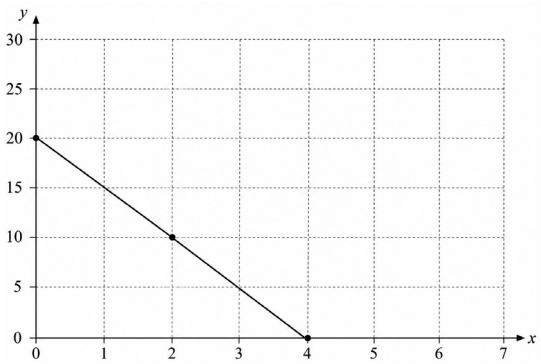
(b) $\text{Displacement} = 0.5 \times \text{base} \times \text{height}$

$= 0.5 \times 4 \times 20$

$= 40\text{m}$

(c) The mathematical area clearly enclosed between the plotted velocity-time graph line and the horizontal time axis always gives the total displacement of the body.

162. Neha was observing a rolling marble on a rough floor. She measured its speed as it gradually slowed down due to friction until it stopped completely. She represented her precise observations on a coordinate system. She references the graph below to accurately calculate the retardation.



(a) Calculate the retardation of the marble from the graph.
(b) Calculate the total distance travelled by the marble before coming to rest.

Ans :

(a) Retardation

$= -\dfrac{(\text{Final vertical value} - \text{Initial vertical value})}{\text{Time interval}}$

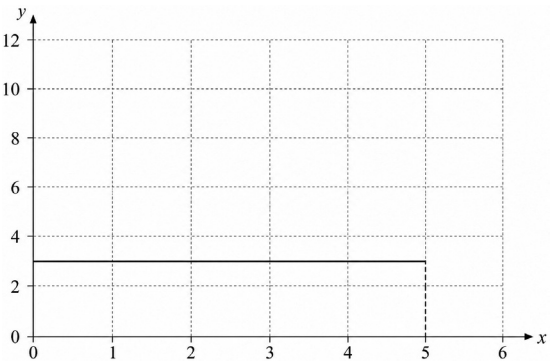
$= -\dfrac{(0-20)}{(4-0)} = 5\text{ms}^{-2}$

(b) $\text{Distance} = \text{Area of triangle}$

$= 0.5 \times \text{base} \times \text{height}$

$= 0.5 \times 4 \times 20 = 40\ \text{m}$

163. Amit monitored the engine output of a miniature train on a straight track. The train maintained a constant rate of increasing its speed for a period of 5 seconds. He plotted his recorded values on a Cartesian plane to strictly analyse the change over time. He references the graph below for his calculations.



(a) Calculate the change in velocity of the miniature train after 5 seconds.
(b) State the type of motion represented by the graph and name the physical quantity represented by the area of the rectangular region.

Ans :

(a) $\text{Change in velocity} = \text{Area of rectangle}$

$= \text{length} \times \text{breadth}$

$= 5 \times 3 = 15\ \text{ms}^{-1}$

(b) 1. The graph represents motion with uniform acceleration because the straight line is perfectly parallel to the horizontal time axis.
2. The area enclosed between the acceleration-time graph and the time axis mathematically represents the exact change in velocity of the moving body.

164. Kavita conducted an experiment where she dropped a metallic sphere from a tall tower. She recorded the distance it fell at various time intervals and squared the time values. She plotted the distance against the squared time values to visually determine the acceleration due to gravity. She references the graph below for her specific findings.

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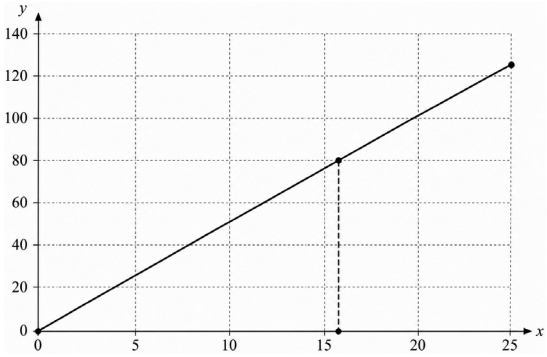


(a) Calculate the slope of the straight line from the given graph.
(b) State the relationship between displacement and the square of time for a freely falling body.
(c) Name the specific physical quantity that is obtained by doubling the slope of this graph.
(d) Calculate the value of acceleration due to gravity from the calculated slope.

Ans :

(a) $\text{Slope} = \dfrac{\text{Change invertical value}}{\text{Change in horizontal value}}$

$= \dfrac{80}{16} = 5\ \text{ms}^{-2}$

(b) For a freely falling body dropped from a height, the total displacement covered is directly proportional to the square of the time taken.

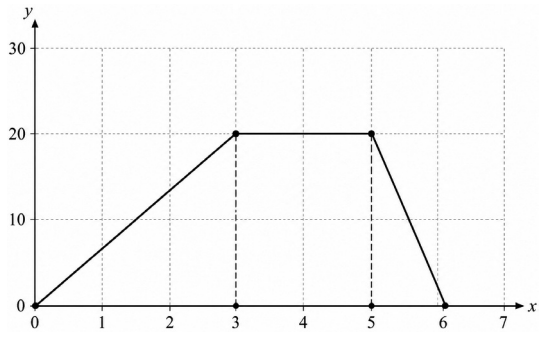
(c) The precise acceleration due to gravity is obtained mathematically by completely doubling the slope of the plotted displacement-time squared graph.

(d) $\text{Acceleration} = 2 \times \text{slope}$

$= 2 \times 5$

$= 10\text{ms}^{-2}$

165. Tarun was analysing the movement of a battery-operated robot moving along a straight track. The robot moved forward, paused for a few seconds to perform a task, and then reversed back to its starting point. He plotted the robot's distance from the start against time. He references the graph below to properly understand the different phases of motion.



(a) Calculate the velocity of the robot during the first 3 seconds.

(b) State the state of the robot between 3 seconds and 5 seconds.
(c) Calculate the velocity of the robot during the last second of its journey.
(d) State the significance of the negative slope in the third segment of the graph.

Ans :

(a) $\text{Velocity} = \dfrac{\text{Final position} - \text{Initial position}}{\text{Timeinterval}}$

$= \dfrac{(20-0)}{3}$

$= 6.67\text{ms}^{-1}$

(b) The robot is completely stationary or at rest between the 3-second and 5-second marks because its physical position does not change.

(c) $\text{Velocity} = \dfrac{\text{Final position} - \text{Initial position}}{\text{Time interval}}$

$= \dfrac{(0-20)}{(6-5)}$

$= -20\text{ms}^{-1}$

(d) The negative slope mathematically indicates that the robot has acquired a negative velocity, meaning it is strictly returning back to its initial starting point.

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CHAPTER 3

Laws of Motion

SUMMARY

1. FORCE

A physical cause which changes (or tends to change) either the size, shape, state of rest, or state of motion of a body.

1.1 Units of Force

SI Unit

One kilogram force is the force due to gravity on a mass of 1 kilogram.

1kgf =1 kg × acceleration due to gravity g in m s^{-2}

= g N

= 9.8 N

Similarly, one gram force is the force due to gravity on a mass of 1 gram.

CGS Unit

The CGS unit of force is the dyne.

$$1 \text{ N} = 10^5 \text{ dyne}$$

Gravitational Units

1gf =1 g × acceleration due to gravity g in cm s^{-2}

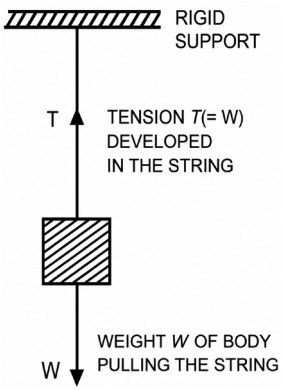
= g dyne

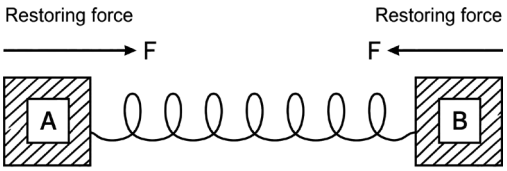
= 980 dyne

1.2 Type of the Forces

The force is classified into the two type which are as follows :

1. **Contact Force : The forces which act on bodies when they are in physical contact are called contact forces.**
   1. Frictional Force : When a body moves over a rough surface, a force acts on the body in a direction opposite to the motion of the body along the surface of contact. This is called the frictional force or the force of friction.
      Example : When a person moves towards the right on a road, the force of friction acts on him towards the left. This force resists his motion on the road.
   2. Normal Reaction Force : When a body is placed on a surface, the body exerts a force equal to its weight in the downward direction on the surface. However, the body does not move (or fall) because the surface exerts an equal and opposite force on it, which is called the normal reaction force.
   3. Tension Force : When a body is suspended by a string, the body pulls the string vertically downwards due to its weight. In its stretched condition, the string pulls the body upwards by a force which balances the weight of the body. This force developed in the string is called the tension force T.





(c) Stretched spring pulls in the objects

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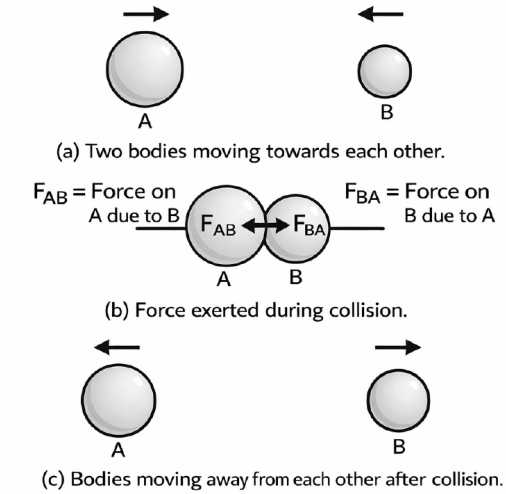
4. Restoring Force : The spring has a tendency to return to its original form. Similarly, when one end of a spring is kept fixed, the spring is found to exert a force at its other end which is directly proportional to the displacement, and the force exerted is in a direction opposite to the direction of displacement. This force is called the restoring force.
5. Force During Collision : When two bodies collide, they push each other. As a result, equal and opposite forces act on each body.



(c) Bodies moving away from each other after collision.

2. Non-Contact Force : The forces experienced by bodies even without being physically touched are called non-contact forces or forces at a distance.

1. Gravitational Force In the Universe, each particle attracts another particle because of its mass. This force of attraction between the particles is called the gravitational force.
2. The force on a body due to the Earth's attraction is called the force of gravity. It causes the movement of the body towards the Earth, i.e., downwards, if the body is free to move. The body also attracts the Earth by an equal amount of force, but no motion is caused in the Earth because of its huge mass.
3. Two like charges repel, while two unlike charges attract each other. The force between the charges is called the electrostatic force.
4. Two like magnetic poles repel each other, while two unlike magnetic poles attract each other. The force between the magnetic poles is called the magnetic force.

General Character of Non-contact Forces

1. The gravitational force is always of an attractive nature, while the electrostatic force and the magnetic force can be either attractive or repulsive.
2. The magnitude of non-contact forces on the two bodies varies inversely as the square of the distance of separation between them. It decreases with an increase in separation and increases as the separation decreases.

2. NEWTON'S FIRST LAW OF MOTION

If a body is in a state of rest, then it will remain in that state, and if the body is in a state of motion, then it will continue moving with the same velocity in the same direction unless an external force is applied on it.

2.1 Inertia

The property of an object by virtue of which it neither changes its state nor tends to change the state is called inertia.

Relationship between Mass and inertia

Mass is a measure of inertia of the body. Greater the mass, greater is the inertia, and thus, more is the resistance to the change in the state of rest or motion.

Kinds of inertia

Inertia is of two kinds:

1 Inertia of rest: If a body is at rest, then it will continue to remain at rest unless an external force is applied.

2 Inertia of motion: If a body is in a state of motion, then it will continue to move at the same speed in the same direction unless an external force is applied to change its state.

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2.2 Linear momentum

The force required to stop a moving body is directly proportional to the mass and velocity of the body.

The momentum 'p' of a body is defined as the product of mass 'm' and velocity 'v' of the body.

$p = mv$

If a body is at rest, then its momentum will be zero.

1. Momentum is a vector quantity.
2. The SI unit of momentum is kg.m/s.

Change in momentum

Change in momentum is $\Delta p = m\Delta v$

Rate of change of momentum

$$= \frac{\text{Change in momentum}}{\text{Time}}$$

$$= \frac{\text{m}(\text{v} - \text{u})}{\text{t}}$$

$$= \text{ma}$$

Thus, the rate of change of momentum is the product of mass and acceleration.

3. NEWTON'S SECOND LAW OF MOTION

The acceleration produced in a body of a given mass is directly proportional to the force applied on it. $a \propto F$

The force needed to produce a given acceleration in a body is directly proportional to the mass of the body. $F = ma$

The SI unit of force is newton (N).

One newton is the force which when acts on a body of mass 1 kg produces an acceleration of 1 m s^{-2}.

$$1 \text{ newton} = 1\,\text{kg} \times 1\,\text{ms}^{-2}$$

The CGS unit of force is dyne where 1 newton $=10^5$ dyne.

Newton's second law in terms of rate of change of momentum

The rate of change of momentum is a product of mass and acceleration.

$$\frac{\Delta p}{\Delta t} = ma$$

However, force is a product of mass and acceleration.

Thus, $$\text{F} = \frac{\Delta p}{\Delta t} = \frac{\Delta (mv)}{\Delta t}$$

Newton's second law statement

The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts.

4. NEWTON'S THIRD LAW OF MOTION

To every action, there is an equal and opposite reaction.

In an interaction of two bodies, there are action and reaction forces present. The action and reaction forces act on two different bodies.

5. UNIVERSAL LAW OF GRAVITATION

Every object in the universe attracts every other object with a force which is proportional to the product of their masses and inversely proportional to the square of the distance between them.

$$F \propto \frac{Mm}{r^2}$$

$$F = \frac{GMm}{r^2}$$

G is the proportionality constant and is known as the universal gravitational constant.

The universal gravitational constant G is independent of

The medium between the two bodies

The masses of the two bodies

The distance of separation between the two bodies

Universal gravitational constant G

$$F = \frac{GMm}{r^2}$$

$$G = \frac{Fr^2}{Mm} = \frac{\text{newton} \times \text{metre}^2}{\text{kilogram} \times \text{kilogram}}$$

1. The SI unit of G is N m^2/kg^2.
2. The value of G is G 6.67×10^{-11} N m^2/kg^2.
3. The gravitational constant is defined as the force of attraction acting between two masses each of mass 1 kg placed at a distance of 1 m from each other.

5.1 Force due to Gravity

The force with which the Earth attracts an object is called the force due to gravity.

If we consider a body of mass m = 1 kg, then the force due to gravity is

$$F = \frac{GMm}{r^2}$$

$$= \frac{(6.67 \times 10^{-11})(5.96 \times 10^{24})}{(6.37 \times 10^{6})^2}$$

$$= 9.8\,\text{N}$$

Thus, we can say that the Earth attracts a body of mass 1 kg with a force of 9.8 N.

6. ACCELERATION DUE TO GRAVITY

Whenever objects fall towards the Earth under the influence of gravitational force alone, we say that the objects are in free fall.

The motion of an object under free fall is an accelerated one. This acceleration is known as acceleration due to gravity 'g'.

This acceleration is the same for all bodies.

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It is a vector quantity directed vertically downwards towards the centre of the Earth.

$g = \frac{GM}{R^2}$

Here, R is the radius of the Earth.

By substituting the values of G,M and R in the above equation, we get

$$= \frac{(6.67 \times 10^{-11})(6 \times 10^{24})}{6.4 \times 10^{6}}$$

$$= 9.8 \text{ m/s}^2$$

7. FREE FALL

The motion of a freely falling body or a body thrown vertically upwards is a one dimensional motion under gravity.

If a body is freely falling, then a = g.

If it is thrown upwards, then a = $-g$.

The equations for a freely falling body with initial velocity $u = 0$ in terms of g are

$$v = gt$$

$$s = \frac{1}{2}gt^2$$

$$v^2\ 2gs$$

Similarly, for a body thrown vertically upwards with initial velocity u, these equations are

$$v = u - gt$$

$$s = ut - \frac{1}{2}gt^2$$

$$v^2 = u^2 - 2gs$$

8. MASS AND WEIGHT

Mass and weight are two fundamental physical quantities that are often confused with each other, but they have different meanings and properties.

8.1 Mass

The amount of matter contained in a body at rest is its mass. It is a scalar quantity. Its SI unit is kilogram (kg). It does not change with change of place of the body. However, when the speed of the body approaches the speed of light, its mass changes.

8.2 Weight

The force with which an object is attracted towards the Earth is the weight of that object. It is written as W = mg . Its unit is newton (N). The difference between mass and weight are as follows:

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Mass	Weight
It is a measure of the amount of matter contained in a body at rest.	It is the force with which the Earth attracts a body.
Its SI unit is kg.	Its SI unit is newton (N).
It is a scalar quantity.	Its SI unit is newton (N)
It is constant for a body and does not change with change in place.	It varies from place to place due to variation in the value of g.

OBJECTIVE QUESTIONS

1. Which of the following effects is produced when a force is applied to a stationary, flexible, and non-rigid body?

(A) It produces a constant velocity in the body.
(B) It changes only the dimensions of the body.
(C) It changes the mass of the body significantly.
(D) It creates a uniform linear acceleration only.

Ans : (B)

A force applied to a stationary flexible object primarily alters its physical dimensions, meaning its size or shape changes. The applied force deforms the non-rigid body rather than initiating uniform motion, demonstrating one of the fundamental macroscopic effects of force.

2. Consider the following statements regarding non-contact forces:

I. They are fundamental forces of nature.
II. Gravitational force can be either attractive or repulsive.
III. Their magnitude varies inversely as the square of the distance.
IV. Magnetic force occurs only between two like poles.

Which of the statements given above are correct?

(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

Ans : (B)

Non-contact forces are fundamental natural forces whose strength follows an inverse square relationship with distance. Gravitational

force is exclusively attractive, never repulsive. Additionally, magnetic forces operate between both like and unlike poles, creating repulsion and attraction respectively across distances.

3. When an object rests on a table, it exerts a downward force equal to its weight. The table exerts an equal and opposite upward force. What is this upward force called?
(A) Force of tension
(B) Frictional force
(C) Normal reaction force
(D) Restoring spring force

Ans : (C)

When a body rests on a surface, the surface exerts an upward force perpendicular to the interface to support the body's weight. This specific contact force prevents the object from falling through and is explicitly termed the normal reaction force.

4. According to Hooke's law, how does the elongation of a spring relate to the force applied, provided it is within the elastic limit?
(A) It is inversely proportional to the applied force.
(B) It is directly proportional to the applied force.
(C) It is proportional to the square of the applied force.
(D) It is independent of the weight suspended from it.

Ans : (B)

Hooke's law establishes that the elongation produced in a spring is directly proportional to the applied stretching force or suspended weight. This proportional relationship holds strictly true as long as the deformation remains within the inherent elastic limit of the material.

5. Which internal property of a body fundamentally determines its tendency to resist any change in its state of rest or motion?
(A) The acceleration of the body
(B) The velocity of the body
(C) The mass of the body
(D) The weight of the body

Ans : (C)

Inertia is the inherent property of an object to resist changes to its state of motion or rest. The mass of the body serves as the direct quantitative measure of this inertia. A heavier body always exhibits significantly greater inertia.

6. **Assertion (A) :** Frictional force is also known as a resistive force.
Reason (R) : Friction occurs due to the attractive intermolecular forces between molecules of different surfaces in close contact.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (B)

Both statements are factually correct. Friction is indeed a resistive force opposing relative motion, and it originates from intermolecular attractions between contacting surfaces. However, the reason does not directly explain why it is classified specifically as a resistive opposing force.

7. An experiment investigates the effects of applying forces to different objects. The observations are recorded in the table below.

Case	Object	Action	Observed Effect
I	Stationary football	A player kicks it	The football moves
II	Moving cricket ball	A fielder catches it	The ball stops moving
III	Clay ball	It is pressed between palms	The ball's shape changes
IV	Rubber band	It is stretched from both ends	The band's length increases

Which pair of cases demonstrates a force changing the state of motion of an object?
(A) Cases I and III
(B) Cases I and II
(C) Cases III and IV
(D) Cases II and IV

Ans : (B)

Force can change an object's state of rest or motion. In Case I, the force puts a stationary object into motion. In Case II, the force stops a moving object. Cases III and IV demonstrate the deforming effect of force, where it changes the shape or size of an object, not its state of motion.

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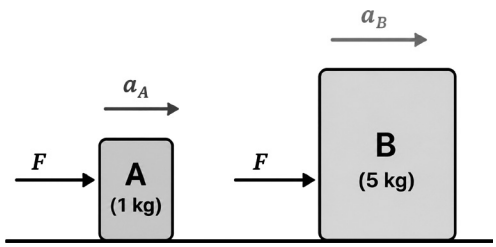
8. What happens to the magnitude of the electrostatic force between two charged bodies if the distance of separation between them is halved?
(A) The force becomes half of its original value.
(B) The force increases by two times.
(C) The force increases by four times.
(D) The force decreases by four times.

Ans : (C)

The magnitude of fundamental non-contact forces obeys the inverse square law regarding distance. If the separation distance between two charged bodies is reduced to half, the resulting electrostatic force increases by a factor of four due to this mathematical relationship.

9. The diagram shows two blocks, A (1 kg) and B (5 kg), on a frictionless surface. An identical force 'F' is applied to each block.



(A) The acceleration of A will be equal to the acceleration of B.
(B) The acceleration of A will be greater than the acceleration of B.
(C) The acceleration of B will be greater than the acceleration of A.
(D) Both blocks will not accelerate as the force is internal.

Ans : (B)

According to Newton's second law, acceleration is inversely proportional to mass for a constant applied force (a = F/m). Since both blocks are subjected to the same force 'F', the block with the smaller mass (Block A) will experience a greater acceleration compared to the block with the larger mass (Block B).

10. When a glass tumbler carrying a thick cardboard and a coin is flicked sharply, the cardboard flies away but the coin drops into the tumbler. Why does this happen?
(A) The coin experiences an intense frictional force.
(B) The coin maintains its state due to inertia of rest.
(C) The coin acquires inertia of motion instantly.
(D) The cardboard exerts a strong gravitational pull.

Ans : (B)

When the cardboard is flicked, it instantly enters a state of motion. However, the coin resists this sudden change due to its inherent inertia of rest. Consequently, it remains stationary horizontally and drops straight down into the tumbler under gravity.

11. Match the scenarios in List-I with the corresponding type of force in List-II.
List-I
P. A stone dropped from a building falls down
Q. Bits of paper attracted to a rubbed glass rod
R. A moving ball stopped by a fielder's hands
S. A body suspended by a vertical string
List-II
I. Electrostatic force
II. Contact force
III. Tension force
IV. Gravitational force
(A) P-IV, Q-I, R-II, S-III
(B) P-I, Q-IV, R-III, S-II
(C) P-IV, Q-II, R-I, S-III
(D) P-III, Q-I, R-II, S-IV

Ans : (A)

A falling stone experiences gravitational attraction. Rubbed glass attracting paper demonstrates electrostatic force. A fielder stopping a ball applies a direct physical contact force. A string holding a suspended mass develops an internal pulling force universally recognized as tension force.

12. **Assertion (A) :** Newton's third law of motion is not applicable to an isolated single body.
Reason (R) : The action and reaction forces always occur simultaneously on two different interacting bodies.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Newton's third law dictates that forces exist solely in pairs. An interaction necessarily requires two distinct objects. Action and reaction forces cannot occur within a single isolated body; they exclusively manifest simultaneously on two separate interacting bodies operating in tandem.

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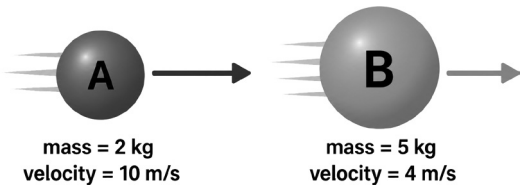
13. Consider the following statements regarding Newton's First Law of Motion:
I. It is also known as Galileo's law of inertia.
II. It provides a quantitative mathematical formula for force.
III. It states that an external force is required to change a body's state of motion.
IV. It implies that a body with zero net force has zero acceleration.
Which of the statements given above are correct?
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

Ans : (B)

Newton's first law, building on Galileo's law of inertia, defines force qualitatively as the external cause necessary to change a body's motion state. It indicates that without net external force, acceleration remains zero. It does not provide quantitative mathematical formulas.

14. Two balls, A and B, are moving as described in the diagram. Their linear momenta are p_A and p_B respectively.



(A) p_A is greater than p_B.
(B) p_B is greater than p_A.
(C) p_A and p_B are equal.
(D) The relationship cannot be determined without knowing the forces applied.

Ans : (C)

Explanation: Linear momentum (p) is calculated as the product of mass (m) and velocity (v).
For ball A, p_A = 2 kg × 10 m/s = 20 kg m/s.
For ball B, p_B = 5 kg × 4 m/s = 20 kg m/s.
Since the calculated values are the same, the linear momenta of the two balls are equal.

15. **Assertion (A) :** A passenger jumping forward from a moving train may fall down in the direction of the train's motion.
Reason (R) : The passenger's feet come to rest upon touching the ground, while the upper body retains inertia of motion.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

When jumping from a moving vehicle, the person's feet abruptly halt upon contacting the stationary ground. Meanwhile, the upper body continues moving forward at the train's speed owing to inertia of motion, causing the individual to topple forward completely.

16. In an experiment, different forces are applied to a body of constant mass, and the resulting acceleration is measured.

Force Applied (N)	Acceleration (m/s²)
10	2.5
20	5.0
30	7.5
X	10.0

Based on Newton's second law of motion, what is the value of the force 'X'?
(A) 35 N
(B) 40 N
(C) 45 N
(D) 50 N

Ans : (B)

According to Newton's second law, for a constant mass, acceleration is directly proportional to the applied force ($F \propto a$). From the table, we can find the constant of proportionality, which is the mass ($m = F/a = 10/2.5 = 4$ kg). To produce an acceleration of 10.0 m/s², the required force is $F = ma = 4 \text{ kg} \times 10.0 \text{ m/s}^2 = 40$ N.

17. Which of the following phenomena is NOT an illustration of the inertia of motion?
(A) An athlete running some distance after crossing the finish line.
(B) Passengers leaning forward when a moving car stops suddenly.
(C) Dust particles falling out when a hanging carpet is beaten.
(D) A bicycle continuing to roll on a road after pedaling stops.

Ans : (C)

Dust particles separating from a suddenly beaten carpet effectively demonstrate the inertia of rest, not the inertia of motion. The carpet moves while the dust remains momentarily stationary. The other given examples clearly illustrate bodies

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retaining their existing forward motion.

18. How is the linear momentum of a moving body mathematically defined in physics?
(A) The sum of its mass and velocity.
(B) The ratio of its mass to its velocity.
(C) The product of its mass and acceleration.
(D) The product of its mass and velocity.

Ans : (D)

Linear momentum is a vector quantity defined mathematically as the direct product of an object's mass and its velocity. It captures the combined effect of these two properties, representing the total amount of motion possessed by the specific physical body.

19. A cricketer catches a ball of mass 150 g (0.15 kg) moving at 20 m/s. The table compares two different catching techniques.

Technique	Action	Time to stop the ball (Dt)	Average Force Felt (F)
A	Hands are kept rigid	0.05 s	60 N
B	Hands are withdrawn	0.50 s	X

Calculate the average force 'X' felt by the player when using technique B.
(A) 600 N
(B) 60 N
(C) 6 N
(D) 0.6 N

Ans : (C)

The change in momentum (impulse) is the same in both cases. Impulse = F × Δt. First, calculate the change in momentum:

$$\Delta p = m(v-u) = 0.15 \times (0 - 20) = -3 \text{ kg m/s}.$$

For technique B,

$$\text{Force X} = \Delta p / \Delta t = -3 / 0.50 = -6 \text{ N}.$$

The magnitude of the force is 6 N. By increasing the time of impact, the player reduces the force.

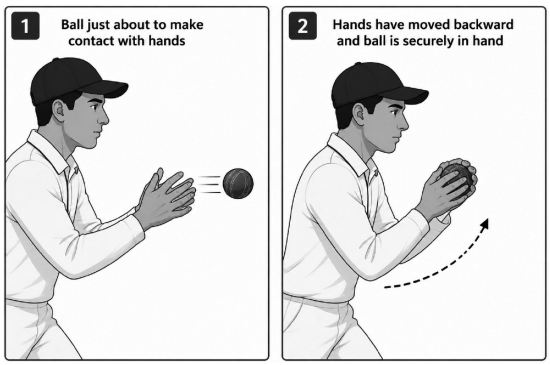
20. Consider the following statements regarding the rate of change of momentum:
I. It is directly proportional to the applied external force.
II. It occurs in a direction opposite to the applied force.
III. It requires the mass of the body to remain constant to equal mass times acceleration.
IV. Its SI unit is newton.

Which of the statements given above are correct?
(A) I and II
(B) I, III, and IV
(C) II, III, and IV
(D) I and IV

Ans : (B)

Newton's second law mandates that momentum change rate is proportional to applied force and occurs in the identical direction, not opposite. When mass is constant, it simplifies to mass times acceleration. Its SI unit strictly matches the unit of force.

21. A cricket player is shown catching a fast-moving ball. The diagram illustrates the technique of moving the hands backward during the catch.



(A) To increase the final momentum of the ball.
(B) To decrease the impulse applied to the ball.
(C) To reduce the force exerted by the ball on the hands by increasing the impact time.
(D) To apply a greater force to the ball to stop it quickly.

Ans : (C)

Explanation: The change in momentum (impulse) of the ball is constant. According to the impulse-momentum theorem ($F\Delta t = \Delta p$), the force (F) is inversely proportional to the time of impact (Δt). By moving the hands backward, the player increases the duration of the impact, which significantly reduces the magnitude of the force exerted by the ball on the hands, preventing injury.

22. If the mass of a moving object remains constant, the change in its linear momentum is directly due to which of the following?
(A) A change in its physical dimensions.
(B) A change in its surrounding temperature.
(C) A change in its velocity.
(D) A change in its chemical composition.

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Ans : (C)

Linear momentum depends strictly on mass and velocity. If the object's mass remains perfectly constant during travel, any measured variation in its momentum is exclusively attributed to a change in its velocity, as described by the standard mathematical equation.

23. A constant force of 50 N is applied to objects of different masses. The acceleration produced in each case is recorded.

Trial	Mass (kg)	Acceleration (m/s^2)
1	2.0	25.0
2	5.0	10.0
3	10.0	5.0
4	25.0	Y

What is the value of acceleration 'Y' in Trial 4?
(A) 1.0 m/s^2
(B) 2.0 m/s^2
(C) 2.5 m/s^2
(D) 5.0 m/s^2

Ans : (B)

Newton's second law states that for a constant applied force, acceleration is inversely proportional to the mass ($a \propto 1/m$). Alternatively, using $F = ma$, we have $a = F/m$. In Trial 4, the mass is 25.0 kg and the constant force is 50 N. Therefore, the acceleration $Y = 50\ N / 25.0\ kg = 2.0\ m/s^2$.

24. What is the exact value of one newton of force when expressed in the CGS unit system?
(A) Ten thousand dyne
(B) One hundred thousand dyne
(C) One million dyne
(D) Ten million dyne

Ans : (B)

Force measurements transition between systems using specific conversion factors. One newton mathematically equals one kilogram multiplied by one meter per second squared. Converting these base units into grams and centimetres respectively yields exactly one hundred thousand dyne as the equivalent.

25. **Assertion (A) :** No external force is required to keep a body moving with a constant uniform velocity.
Reason (R) : When a body moves with a constant velocity, its acceleration is zero, resulting in a net force of zero.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

A body exhibiting constant uniform velocity undergoes no acceleration. According to Newton's second law, force equates to mass multiplied by acceleration. Therefore, zero acceleration necessitates zero net external force, completely validating both the stated assertion and its accompanying logical reason.

26. When a constant force is applied to different bodies, what is the geometric shape of the graph plotted between the acceleration produced and their respective masses?
(A) A straight line passing through the origin
(B) A straight line parallel to the mass axis
(C) A hyperbolic curve
(D) A parabolic curve

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Ans : (C)

When a constant force acts upon objects of differing masses, the acceleration produced becomes inversely proportional to their respective masses. Plotting this specific inverse mathematical relationship between acceleration and mass naturally yields a distinctly curved graph known as a hyperbola.

27. Which term describes the combined effect of a large force acting on a physical body for an exceedingly short duration of time?
(A) Power of force
(B) Work done by force
(C) Pressure of force
(D) Impulse of force

Ans : (D)

In physics, an extremely large force applied over a remarkably brief time interval produces a substantial change in momentum. This distinct physical phenomenon, frequently observed in rapid collisions or impacts, is explicitly defined and categorized as the impulse of force.

28. Why does an athlete prefer to land on a foam mattress rather than a hard cemented floor after a long jump?
(A) The foam reduces the athlete's total change in momentum.
(B) The foam increases the time interval of the impact, decreasing the force.

(C) The foam completely eliminates the athlete's inertia of motion.
(D) The foam applies an electrostatic repulsive force on the athlete.

Ans : (B)

Landing on foam significantly extends the time duration required for the athlete to completely halt. Because the total momentum change remains constant, this increased time interval drastically decreases the overall impact force exerted on the feet, effectively preventing severe injury.

29. Which of the following statements about action and reaction forces is inherently incorrect?
(A) They are equal in their overall magnitude.
(B) They act in entirely opposite directions.
(C) They always cancel each other out to produce zero net force.
(D) They act simultaneously without any time delay.

Ans : (C)

Although action and reaction forces possess equal magnitudes and strictly opposite directions, they never cancel each other out. This lack of cancellation occurs primarily because they invariably act upon two completely different physical bodies, rather than acting on the same object.

30. How is the gravitational force between two masses mathematically related to the distance separating their centres?
(A) It is directly proportional to the separation distance.
(B) It is directly proportional to the square of the distance.
(C) It is inversely proportional to the separation distance.
(D) It is inversely proportional to the square of the distance.

Ans : (D)

Newton's universal law explicitly establishes that the gravitational attraction connecting two separate physical bodies significantly weakens as their distance increases. Specifically, it strictly obeys an inverse square relationship relative to the exact measured distance between the two bodies' respective centres.

31. Match the physical quantities in List-I with their correct SI units in List-II.
List-I
P. Force
Q. Linear Momentum
R. Rate of change of momentum
S. Impulse
List-II
I. Kg m s^{-1}
II. Newton
III. Newton second
IV. Kg m s^{-2}
(A) P-II, Q-I, R-IV, S-III
(B) P-IV, Q-III, R-II, S-I
(C) P-II, Q-III, R-IV, S-I
(D) P-I, Q-II, R-III, S-IV

Ans : (A)

Force and the rate of change of momentum are both measured in newton, which equals kg m s^{-2}. Linear momentum has the specific unit of kg m s^{-1}. Impulse, calculated as force multiplied by time, is accurately measured in newton second.

32. The relationship between a non-contact force (F) and the separation distance (r) between two bodies is investigated. The data is recorded as follows.

Trial	Separation Distance	Magnitude of Force
1	r	36 F
2	2r	9 F
3	3r	X
4	6r	F

What is the value of X that correctly completes the pattern?
(A) 6 F
(B) 4 F
(C) 12 F
(D) 18 F

Ans : (B)

The magnitude of non-contact forces like gravitational and electrostatic forces varies inversely as the square of the distance between the bodies ($F \propto 1/r^2$). From trial 4 to trial 1, the distance becomes 1/6th, and the force becomes 36 times. For trial 3, the distance is 3r. Compared to trial 4 (6r), the distance is halved, so the force should be 4 times greater, making X = 4F.

33. Consider the following statements regarding the recoil of a gun:
I. The gun moves backwards when a bullet is fired.
II. The force exerted on the bullet is the action force.

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III. The recoil force experienced by the gun is the reaction force.
IV. The gun and the bullet undergo equal acceleration.
Which of the statements given above are correct?
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

Ans : (A)

Firing a gun wonderfully illustrates action and reaction principles. The forward force propelling the bullet represents the action, while the gun's backward recoil acts as the reaction. However, their resulting accelerations differ significantly because the gun's mass vastly exceeds the bullet's.

34. In the context of rocket motion, what generates the necessary reaction force that propels the rocket forward?
(A) The atmospheric friction against the rocket body
(B) The intense gravitational pull of the Earth
(C) The downward ejection of high-speed exhaust gases
(D) The ambient air pressure surrounding the rocket

Ans : (C)

A rocket engine aggressively expels combustion gases downwards at tremendously high velocities. This forceful downward expulsion acts as the primary action force. Consequently, the escaping gases exert an equal and completely opposite upward reaction force, successfully driving the rocket forward.

35. Which of the following pairs correctly matches the physical quantity with its precise characteristic?
(A) Universal gravitational constant - Vector quantity
(B) Acceleration due to gravity - Varies from place to place
(C) Mass of a body - Vector quantity
(D) Weight of a body - Remains completely constant everywhere

Ans : (B)

Acceleration due to gravity significantly varies with location, maximizing at the poles and minimizing at the equator. Mass and the universal gravitational constant are strictly scalar and constant quantities. Weight is an environmental variable that depends directly on local gravity.

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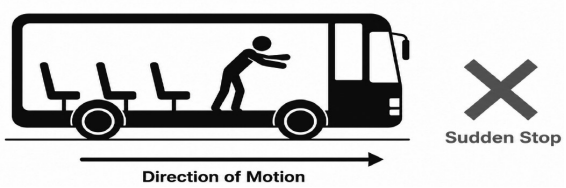
36. Identify the correct sequence of fundamental steps to calculate the acceleration due to gravity on the Earth's surface.
I. Equate the force of gravity to the body's weight (mg).
II. Cancel the mass of the object (m) from both sides.
III. Write the expression for universal gravitational force ($F = GmM/R^2$).
IV. Obtain the final formula $g = GM/R^2$.
(A) III, I, II, IV
(B) I, III, IV, II
(C) III, II, I, IV
(D) I, II, III, IV

Ans : (A)

First, the universal gravitational force expression is formulated. Next, this force is equated to the weight of the object as defined by the second law. Subsequently, the object's mass mathematically cancels out, naturally yielding the isolated expression for gravitational acceleration.

37. The diagram illustrates a passenger standing in a bus that is moving and then suddenly stops. The passenger is shown leaning forward.



(A) Inertia of rest causes the passenger's entire body to stop with the bus.
(B) Inertia of motion keeps the passenger's upper body moving forward while their feet stop with the bus.
(C) The reaction force from the bus floor pushes the passenger forward.
(D) The sudden stop creates a forward force that acts on the passenger's upper body.

Ans : (B)

This phenomenon is an example of inertia of motion. When the bus is moving, the passenger's entire body is also in motion. Upon a sudden stop, the passenger's feet, being in contact with the bus floor, come to rest immediately. However, the upper part of the body tends to continue its state of motion, causing the passenger to lurch forward.

38. **Assertion (A) :** The value of the universal gravitational constant (G) is completely

independent of the medium between the two bodies.

Reason (R) : The value of G changes if the masses of the interacting bodies are drastically increased.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The universal gravitational constant fundamentally remains entirely unchanged irrespective of the surrounding medium, spatial distance, or physical mass of the bodies involved. Therefore, the stated assertion is absolutely true, whereas the accompanying reason claiming G changes with mass is demonstrably false.

39. If a freely falling object travels towards the Earth entirely in a vacuum, which of the following statements accurately describes its motion?

(A) Its acceleration continuously increases at a uniform rate.
(B) Its velocity continuously increases at a uniform rate.
(C) Its mass gradually decreases as it falls.
(D) Its weight completely vanishes during the descent.

Ans : (B)

During free fall in a vacuum, an object constantly experiences a uniform downward acceleration due strictly to gravity. Because this acceleration remains perfectly steady, the object's downward velocity continuously increases at an absolutely constant uniform rate throughout its downward journey.

40. What is the approximate value of the acceleration due to gravity precisely at the geographical center of the Earth?

(A) 9.8 m s^{-2}
(B) 1.6 m s^{-2}
(C) Infinity
(D) Zero

Ans : (D)

The overall magnitude of gravitational acceleration exhibits noticeable variation depending fundamentally on both altitude and depth. As one travels progressively deeper beneath the surface, gravity decreases, ultimately reaching exactly zero when perfectly positioned at the geographical center of the Earth.

41. Consider the following statements regarding the mass of a physical body:

I. It is the measure of the body's fundamental inertia.
II. It is a strictly scalar physical quantity.
III. It is commonly measured using a standard spring balance.
IV. It remains entirely constant regardless of geographical location.

Which of the statements given above are correct?

(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (B)

Mass quantifies inherent inertia, exists as a true scalar quantity, and maintains absolute constancy across various locations. However, it is accurately measured employing a physical beam balance, whereas a spring balance serves specifically to measure an object's varying gravitational weight.

42. The table below lists pairs of interacting bodies and the action force.

Case	Action Force	Reaction Force
I	Force of a bullet on a target	Force of the target on the bullet
II	Force of a hammer on a nail	Force of the hammer on the user's hand
III	Weight of a book on a table	Force of the Earth on the book
IV	Force of a boatman's oar pushing water backward	Z

According to Newton's third law of motion, which statement correctly describes the reaction force 'Z'?

(A) The force of the boatman on the oar.
(B) The force of the water pushing the boat forward.
(C) The force of gravity on the water.
(D) The force of friction between the boat and water.

Ans : (B)

Newton's third law states that for every action, there is an equal and opposite reaction acting on the other body. The action is the oar pushing the water backward. The reaction must be the water exerting an equal and opposite force on the oar (and thus the boat), pushing it forward. The

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other options are incorrect pairs.

43. Which of the following pairs concerning the physical units of force is incorrectly matched?
(A) SI unit of force - newton
(B) CGS unit of force - dyne
(C) Gravitational unit in SI system - gram force
(D) Gravitational unit in MKS system - kilogram force

Ans : (C)

In the globally accepted SI system, the recognized gravitational unit of force is explicitly kilogram force. Conversely, gram force specifically functions as the corresponding gravitational unit within the older CGS system, rendering the stated pairing strictly incorrect by definition.

44. If the average acceleration due to gravity on Earth is 9.8 m s^{-2}, what is the exact equivalent value of 1 kgf in newtons?
(A) 1 N
(B) 9.8 N
(C) 980 N
(D) 1000 N

Ans : (B)

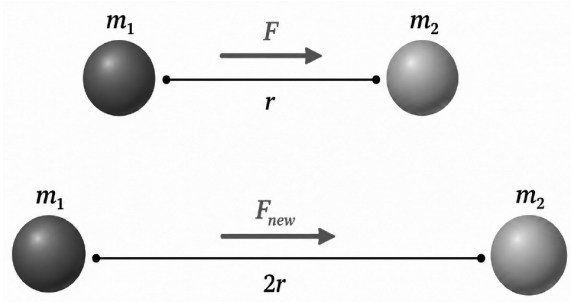
One kilogram force represents the precise gravitational force exerted by the Earth on a one-kilogram mass. By applying Newton's second law, multiplying the one-kilogram mass by the standard gravitational acceleration naturally yields exactly nine point eight newtons of applied force.

45. In the laboratory demonstration of Newton's third law using two interconnected spring balances, what critical observation explicitly validates the law?
(A) Both spring balances display identically zero readings.
(B) The pulling balance shows a significantly higher reading.
(C) Both spring balances continuously show identical positive readings.
(D) The anchored balance entirely fails to register any force.

Ans : (C)

When pulling two interconnected spring balances, the primary force applied acts directly against the opposing reactive pull. Both interconnected instruments continuously register perfectly identical force values, visually proving that action and reactive forces are perpetually equal in their total magnitudes.

46. The diagram shows two masses, m_1 and m_2, interacting via gravitational force. Initially, they are separated by a distance 'r' experiencing force 'F'. The distance is then increased to '2r'.



(A) $F_{new} = \frac{F}{2}$
(B) $F_{new} = \frac{F}{4}$
(C) $F_{new} = 2F$
(D) $F_{new} = 4F$

Ans : (B)

According to Newton's Universal Law of Gravitation, the force of attraction 'F' is inversely proportional to the square of the distance 'r' between the centers of the two bodies ($F \propto 1/r^2$). If the distance is doubled from 'r' to '2r', the new force will be proportional to $1/(2r)^2$, which is $1/(4r^2)$. Therefore, the new force will be one-fourth of the original force.

47. Why does the Earth fail to visibly move towards a small falling object despite experiencing an equal gravitational force of attraction?
(A) The object lacks sufficient mass to generate real gravity.
(B) The Earth's immense mass prevents any significant acceleration.
(C) The surrounding air completely shields the Earth from attraction.
(D) The inverse square law strictly prevents planetary motion.

Ans : (B)

Although Newton's third law confirms identical mutual gravitational attraction, the resulting acceleration depends inversely on physical mass. Because the Earth possesses an overwhelmingly massive inertia, the identical attractive force generates a practically negligible, immeasurably small acceleration on the planet itself.

48. When a moving bus halts abruptly, the passengers sitting inside tend to lean sharply forward. What

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physical mechanism causes this observable effect?
(A) The lower body maintains an uninterrupted inertia of motion.
(B) The upper body retains its forward inertia of motion.
(C) The passengers simultaneously acquire an inertia of rest.
(D) The sudden braking generates an intense gravitational surge.

Ans : (B)

Upon sudden braking, the passenger's lower body safely halts alongside the stopping vehicle. However, owing to fundamental inertia, the unsupported upper body actively resists this sudden deceleration, naturally maintaining its prior forward velocity and causing the characteristic forward leaning motion.

49. According to the specialized equations of motion governing free fall under gravity, what accurately describes the acceleration (a) of a body thrown vertically upwards?
(A) The acceleration continuously increases.
(B) The acceleration remains equal to +g.
(C) The acceleration is replaced by -g.
(D) The acceleration directly depends on initial velocity.

Ans : (C)

Whenever a physical body is forcefully projected vertically upward, its motion actively opposes the Earth's natural downward gravitational pull. Consequently, this upward journey experiences constant retardation, forcing the standard acceleration variable to be mathematically replaced by negative g throughout.

50. Which unique terminology specifically designates the fundamental attractive force existing between entirely ordinary, non-planetary bodies in the universe?
(A) Force due to planetary gravity
(B) Strong intermolecular force
(C) General electrostatic force
(D) Universal gravitational force

Ans : (D)

Every physical mass universally attracts every other mass within the universe. While attraction towards the Earth defines localized gravity, the broader phenomenon occurring between any two generic masses is appropriately termed the universal gravitational force of attraction in physical sciences.

51. What specific internal property of an interacting body is predominantly responsible for creating its characteristic inertia?
(A) Its overall structural volume
(B) Its physical shape
(C) Its fundamental mass
(D) Its inherent velocity

Ans : (C)

Inertia heavily dictates an object's natural tendency to resist any sudden modification of its prevailing kinematic state. This intrinsic resistive property fundamentally depends upon the physical mass contained within the body, making mass the sole quantifiable measure of physical inertia.

ONE MARK QUESTIONS

52. Name the two kinds of inertia.

Ans :
The 2 kinds of inertia are:
(i) Inertia of rest, (ii) Inertia of motion.

53. State the S.I. units of (a) mass and (b) weight.

Ans :
(a) S.I. unit of mass is kilogram (kg).
(b) S.I. unit of weight is newton (N).

54. Name the physical quantity which causes motion in a body.

Ans :
Physical quantity which caused motion in a body is force.

55. What do you understand by the term force due to gravity ?

Ans :
The force with which earth attracts a body is called force due to gravity on that body.

56. State whether the gravitational force between two masses is attractive or repulsive ?

Ans :
Gravitational force between two masses is always attractive.

57. Give one example in each case where :
(a) the force is of contact, and
(b) force is at a distance.

Ans :
(a) Frictional force
(b) Gravitational force.

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58. A ball is moving on a perfectly smooth horizontal surface. If no force is applied on it, will its speed decrease, increase or remain unchanged ?

Ans :
The speed will remain unchanged.

59. Write down the average value of g on the earth's surface.

Ans :
The average value of g is 9.8 ms^{-2} Or 9.8 N.

60. How are g and G related ?

Ans :

$$g = \frac{GM}{R^2}$$

61. State one factor on which the magnitude of a non-contact force depends. How does it depend on the factor stated by you?

Ans :
Distance ; Magnitude of force decreases as the distance increases.

62. Define gravitational constant G.

Ans :
Gravitational constant G is defined as the force of attraction acting between two masses each of mass 1 kg .placed at a separation of 1 m.

63. State Newton's third law of motion.

Ans :
Newton's third law of motion states "to every action there is an equal and opposite reaction." It is useful for rocket propulsion.

64. Write the numerical value of gravitational constant
G with its S.I. unit.

Ans :

$$G = 6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$$

65. Define the term acceleration due to gravity ? Write its S.I. unit.

Ans :
The acceleration produced in a freely falling body due to the attraction of earth is called attraction due to gravity SI unit is ms^{-2}.

66. Explain the meaning of the following statement 1 kgf = 9.8 N.

Ans :
1 kgf = 9.8 N means that a body of mass 1 kg is attracted towards the centre of the earth with a force of 9.8 N.

67. Define a contact force.

Ans :
The forces which act on bodies when they are in actual contact, are called the contact forces. Two examples are as below :
(i) Force of friction
(ii) Force of tension.

68. Non-contact forces.

Ans :
The forces which act on bodies without being physically touched, are called the non-contact forces or the forces at a distance. The gravitational force, electrostatic force and magnetic force are the non-contact forces.

69. A person pushing a wall hard is liable to fall back. Give reason.

Ans :
A person pushing a wall hard is liable to fall back because when he pushes (action) the wall, the wall exerts an equal force (reaction) on him due to which he may fall back.

70. A light ball falling on ground, after striking the ground rises upwards. Explain the reason.

Ans :
While a light ball fall on ground, the ball exerts a force (action) on the hand of ground and the ground exerts an equal force (reaction) on the ball to rises it upward.

71. How does the gravitational force of attraction between two masses depend on the distance between them ?

Ans :
The gravitational force of attraction between two masses is inversely proportional to the square of the distance between them.

72. What is the importance of the law of gravitation ?

Ans :
This law helps us in understanding the motion of planets around the sun, the motion of moon around the earth and the motion of the freely falling bodies.

73. Is force needed to keep a moving body in motion ?

Ans :
In absence of force, after bringing an object in motion, no force is required to keep it moving. In other words, an object, if once in motion, moves with uniform velocity if no force acts on it.

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74. When a shot is fired from a gun, the gun gets recoiled. Explain.

Ans :
When shot is fired from a gun, force acting on bullet in forward direction is action and an equal and opposite force acts on gun called reaction and the gun recoils (gets backward jerk).

75. Comment on the statement 'the sum of action and reaction on a body is zero'.

Ans :
The given statement is wrong because action and reaction never act on the same body. They act simultaneously on two different bodies.

76. Define the terms mass and weight.

Ans :
Mass : The quantity of matter contained in a body is known as its mass.
Weight : Weight of a body is defined as the force with which the earth attracts it.

77. 'The action and reaction both act simultaneously.' Is this statement true ?

Ans :
Yes, the given statement is true because action and reaction both act simultaneously on two different bodies. They are present always in a pair.

78. 'The action and reaction are equal in magnitude.' Is this statement true ?

Ans :
Thus given statement is true.
'Action and reaction are equal in magnitude but both act on two different bodies in opposite directions'.

79. What is the C.G.S. unit of force? How is defined?

Ans :
C.G.S. unit of force is dyne.
One dyne is defined as the force which when acts on a body of mass 1 gram produces an acceleration of 1 cm s^{-2}, i.e. 1 g $\times$ 1 cm s^{-2}

80. What is the Galileo's law of inertia ?

Ans :
According to Galileo's law of inertia - a body continues to be in the state of rest or in the state of uniform motion unless an external force is applied on it.

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81. When you step ashore from a stationary boat, it tends to leave the shore. Explain.

Ans :
When you step ashore, you push the boat with foot in the backward direction [Action]. The boat exerts an equal force on you in the forward direction [Reaction] and enables you to move forward.

82. An aeroplane is moving uniformly at a constant height under the action of two forces (i) upward force (lift) and (ii) downward force (weight). What is the net force on the aeroplane.

Ans :
As aeroplane is moving uniformly at a constant height and two equal and opposite forces are working whose sum is equal to zero.

83. Define linear momentum ans state its S.I. unit.

Ans :
Linear momentum is the quantity of motion possessed by a body and is defined as the product of its mass and velocity. It is a vector quantity and is represented by $p = m \times v$
S.I. unit is kg ms^{-1}

84. Name the S.I. unit of force and define it.

Ans :
The S.I. unit of force is newton (N).
One newton is defined as the force which when acts on a body of mass 1 kg produces an acceleration of 1 ms^{-2}, i.e.

1 newton = 1 kg $\times$ 1 ms^{-2}

85. Name of S.I. and C.G.S. units of force. How are they related?

Ans :
The S.I. unit of force N (newton) an C.G.S. units is dyne.The Relation between newton and dyne is as follows :
Relation : 1 newton $=10^5$ dyne.

86. Write an expression for the gravitational force of attraction between two bodies of masses m_1 and m_2 separated by a distance r.

Ans :
The expression for the gravitational force of attraction between two bodies of masses m_1 and m_2 separated by a distance r is $F = \frac{Gm_1m_2}{r^2}$
Where G is the universal gravitational constant.

87. Give qualitative definition of force on the basis of Newton's first law of motion.

Ans :
The qualitative definition of force on the basis of Newton's first law of motion is : "Force is that external cause which tends to change the state of rest or the state of motion of an object."

88. Name the factor on which inertia of a body depends and state how does it depend on the factor stated by you.

Ans :
The factor on which inertia of a body depends is mass.
Mass is the measure of inertia of a body.
More the mass of a body, more is its inertia.

89. State the Newton's first law of motion.

Ans :
Newton's first law of motion states that "A body at rest will remain at rest, and a body in motion will continue in motion in a straight line with uniform speed, unless it is compelled by an external force to change its state of rest or of uniform motion."

90. The separation between two masses is reduced to half. How is the magnitude of gravitational force between them affected?

Ans :
The force of gravitation between two masses according to law of gravitation is inversely proportional to square of the distance, The distance between two masses is reduced to half, The force between two masses will be four times.

91. Give one example of each of the following (a) inertia of rest, and (b) inertia of motion.

Ans :
(i) Inertia of rest : When we beat a carpet with a stick, dust particles fall of due to inertia of rest and that part of carpet moves ahead.
(ii) Inertia of motion : A man standing in a moving bus falls forward as soon as the bus stops, due to the inertia of motion of upper part of his body. o

TWO MARKS QUESTIONS

92. Explain the motion of a rocket with the help of Newton's third law.

Ans :
The hot gases produced by the fast burning fuel rush out of a jet at the bottom of the rocket at a very high speed is the action and an equal and opposite force is exerted on rocket called reaction pushes the rocket upward with great speed.

93. Two equal and opposite forces act on a stationary body. Will the body move ? Give reason to your answer.

Ans :
Two equal and opposite forces cancel each other when both of them act on the same body in the same line and body does not move. Net force on the body is zero, so the body will remain stationary due to inertia of rest.

94. Give one example in each of the following cases where a force :
(a) Stops a moving body.
(b) Moves a stationary body.
(c) Changes the size of a body.
(d) Changes the shape of a body.

Ans :
(a) A fielder stops the ball by hand.
(b) A ball is kicked
(c) Loading a spring
(d) Hammering of a small piece of silver.

95. Which of the following quantity does not change by change of place of a body : mass or weight ?

Ans :
For a body, mass is constant. It is because, the weight of a body of mass (m) is given by $W = mg$
The value of g varies from place to place.
The weight of the body also varies from place to place. But mass of a body is the total quantity of matter contained in it which remains constant at all places in this universe.

96. Why does a person fall when he jumps out from a moving train ?

Ans :
A person falls when he jumps out from a moving train because inside the train his whole body was in a state of motion along with the train and on jumping out of the train, the lower part of his body comes to rest when his feet touch the ground while the upper part remains in motion due to inertia of motion. It makes him fall in the direction of motion of the train.

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97. To move a boat ahead in water, boatman has to push the water backwards by his oar. Explain.

Ans :
To move a boat ahead in water, the boatman pushes (action) the water backwards by his oar so that water exerts equal and opposite force (reaction) in the forward direction on the boat due to which the boat moves ahead.

98. Why does a coin placed on a card drop into the tumbler when the card is rapidly flicked with the finger ?

Ans :
A coin placed on a card drops into the tumbler when the card is rapidly flicked with the finger because when the card is flicked, it moves away but the coin placed on it tends to remain at rest due to inertia of rest and falls down into the tumbler due to the pull of gravity.

99. How is the acceleration due to gravity on the surface of earth related to its mass and radius ?

Ans :
The acceleration due to gravity (g) is related to the mass (M) and radius of earth (R) by the relation.

$$\mathrm{g} = \frac{GM}{R^2}$$

Greater the mass of earth, greater is gravity.

100. People often shake branches of a tree for getting down its fruits. Why?

Ans :
On shaking (or giving jerks to) the branches of a tree, the fruits fall down. The reason is that when the stem (or branches) of the tree are shaken, they come in motion, while the fruits due to inertia, remain in the state of rest. Thus, the massive and weakly attached fruits get detached from the branches and fall down due to the pull of gravity.

101. State the usefulness of Newton's third law of motion.

Ans :
Usefulness of Newton's third law of motion are :
(i) A gun recoils when a bullet is fired from it.
(ii) A man walking on the ground.
(iii) Rowing a boat.
(iv) A perSon is moving forward during swimming.
(v) Rocket propulsion.

102. A body is thrown vertically upwards with an initial velocity u. Write expression for the maximum height attained by the body.

Ans :
As velocity of body at highest point is zero.
Maximum height attained h can be obtained by

Putting $v = 0$ in

$$v^2 - u^2 = 2(-\mathrm{g})h$$
$$0 - u^2 = -2\mathrm{g}h$$
$$h = \frac{u^2}{2\mathrm{g}}$$

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103. The value of g at the centre of earth is zero. What will be the weight of a body of mass m kg at the centre of the earth ?

Ans :
The weight (W) of a body is related to its mass (m)
as $W = mg$
At the centre of the earth,

$$\mathrm{g} = 0$$
$$W = m \times 0$$
$$= 0$$

i.e. Weight of a body at the centre of the earth is zero.

104. A ball moving on a table top eventually stops. Explain the reason.

Ans :
It has been concluded by various experiments that in absence of force of friction, after bringing an object in motion, no force is required to keep it moving. And as soon as the force of friction acts the object is no longer in motion. Similarly, a ball moving on a table top eventually stops because of the force of friction between the ball and plane, which stops the ball.

105. When two spring balances joined at their free ends, are pulled apart, both show the same reading. Explain.

Ans :
When two spring balances joined at their free ends are pulled apart, both show the same reading in accordance with Newton's third law of motion. The pull on one spring by the other spring is the action and the pull on the second spring due to the first spring is the reaction which are equal and opposite. Consequently both the springs show the same reading.

106. What is meant by the term inertia ?

Ans :

Inertia is the property of a body by virtue of which it resists any change in its state of rest or state of uniform motion in a straight line. In other words, a body tends to remain at rest or continue moving unless acted upon by an external force. This property depends on the mass of the object; greater the mass, greater is the inertia.

107. Give two examples to show that greater the mass, greater is the inertia of the body.

Ans :

(i) It is easier to stop an empty truck than a loaded truck by applying force or brakes.

(ii) A stone has greater inertia than a foot-ball of same size. If we kick a stone, it will not move because of its high inertia but if we kick a foot-ball, it will move a long way.- Thus, a stone resists a change in its state better than a foot¬ball does.

108. How is the gravitational force between two masses affected if the separation between them is doubled?

Ans :

We know that,

$$F \propto \frac{1}{r^2} \quad F' \propto \frac{1}{(2r)^2}$$

$$\frac{F'}{F} = \frac{1}{4r^2} \times r^2 = \frac{1}{4}$$

or $$F' = \frac{F}{4}$$

The gravitational force between two masses is reduced to one - fourth if the separation between them is doubled.

109. A body falls freely under gravity from rest and reaches the ground in time t. Write expression for the height fallen by the body.

Ans :

When a body is falling freely

Under gravity, expression for finding the height is

$$h = ut + \frac{1}{2}gt^2$$

But as body falls from rest, its initial velocity

$$u = 0$$

$$h = O + \frac{1}{2}gt^2$$

or $$h = \frac{1}{2}gt^2$$

110. Write the mathematical form of Newton's second law of motion. State condition if any.

Ans :

The mathematical form of Newton's second law of motion is :

$$F = ma \text{ i.e. force} = \text{mass} \times \text{acceleration}$$

Condition:

Mass should remain constant i'e' V $<<$C i.e. the velocity of body should be upto 10^6 ms^{-1} when the variation in mass with velocity is not very perceptible.

111. Name the two factors on which the force needed to stop a moving body in a given time, depends.

Ans :

The two factors on which the force needed to stop a moving body in a given time depends are mass of the body and velocity of the body. Greater the mass of the body, greater is the force needed to stop it. Similarly, greater the velocity of the body, greater is the force needed to stop it. These two factors together determine the momentum of the body, and greater the momentum, greater is the force required to stop it in a given time.

112. State Newton's second law of motion. What information do you get from it?

Ans :

Newton's second law of motion states that rate of change of momentum is direct proportional to force applied and takes place in the direction of force' We get information that the rate of change of momentum of a body is directly proportional to the force applied on it and the change in momentum takes place in the direction in which the force is applied.

113. Write an expression for the force due to gravity on a body of mass m and explain the meaning of the symbols used in it.

Ans :

The force due to gravity acting on a body of mass m is given by

$$F = \frac{GMm}{R^2}$$

$$mg = \frac{GMm}{R^2}$$

$$g = \frac{GM}{R^2}$$

Where G = Universal gravitational constant, g acc. due to gravity

M = Mass of earth

and R = Radius of earth

114. State the effects of a force applied on (i) a non-rigid, and (ii) a rigid body. How does the effect of

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the force differ in the two cases?

Ans :

(i) When a force applied on a non-rigid body, it changes the inter-spacing between its constituent particles and therefore causes a change in its dimensions and can also produce motion in it.

(ii) When a force is applied on a rigid body, it does not change the inter-spacing between its constituent particles and therefore it does not change the dimensions of the object but causes only the motion in it.

115. Explain by giving two examples each of :

(a) Contact forces, and

(b) Non-contact forces.

Ans :

(a) The forces which act on bodies when they are in actual contact, are called the contact forces. Two examples are as below :

(i) Force of friction

(ii) Force of tension.

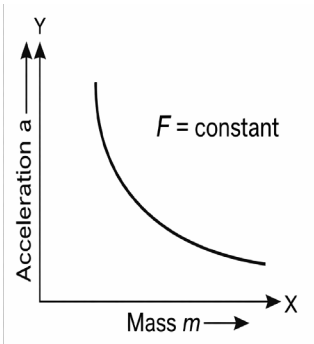
(b) The forces which act on bodies without being physically touched, are called the non-contact forces or the forces at a distance. The gravitational force, electrostatic force and magnetic force are the non-contact forces.

THREE MARKS QUESTIONS

116. How does the acceleration produced by a given force depend on mass of the body? Draw graph to show it.

Ans :

If a given force is applied on bodies of different masses, the acceleration produced in them is inversely proportional to their masses i.e. $a \propto \frac{1}{m}$ (for a given force F). A graph plotted for acceleration (a) against mass (m) is hyperbola.



Graph showing the variation of acceleration with mass.

117. How does Newton's second law of motion differ from first law of motion?

Ans :

Newton's First Law of Motion tells us about the state of an object when no net force acts on it. It gives only the qualitative idea of force, meaning it tells us that a force is needed to change the state of motion but does not tell us how much force is needed.

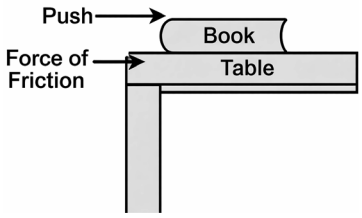
Newton's Second Law of Motion tells us what happens when an unbalanced force acts on an object. It gives the quantitative idea of force through the formula F = ma, which helps us calculate the exact amount of force required.

Therefore, the first law gives the condition of motion when force is absent, while the second law gives the exact relationship between force, mass and acceleration when force is present.

118. What is a frictional force ? Draw a neat labelled diagram showing a frictional force acting on a body.

Ans :

Frictional force is a type of contact force that opposes the motion or attempted motion of two surfaces that are in contact. When an object is in contact with another surface, there can be microscopic irregularities on the surfaces that cause them to stick together, making it difficult to slide over each other. Frictional force acts in the opposite direction to the direction of motion or the direction in which the object would move if the frictional force was not present.



119. Two equal and opposite forces act on a moving object. How is its motion affected ? Give reason.

Ans :

When two equal and opposite forces act on a moving object, the object continues to move with the same speed in the same direction without any change. This is because the two equal and opposite forces cancel each other out and the net force acting on the object becomes zero. According

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to Newton's First Law of Motion, if the net force acting on an object is zero, the object will not change its state of motion. Since the object is already moving, it will continue to move with the same velocity. Therefore, the motion of the object remains unaffected and it keeps moving with constant speed in the same direction.

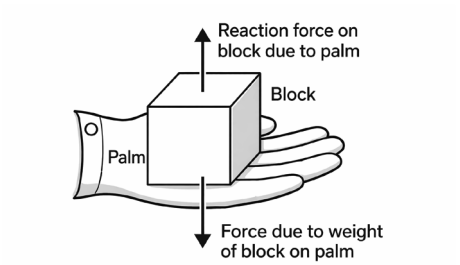
120. State and explain the law of inertia (or Newton's first law of motion).

Ans :
Newton's First Law of Motion, also known as the law of inertia, states that a body remains at rest or continues to move with uniform velocity in a straight line unless acted upon by an external unbalanced force.

This law explains that objects resist any change in their state due to inertia. A body at rest will not start moving, and a moving body will not stop or change direction on its own. The greater the mass of the body, the greater is its inertia. For example, passengers fall forward when a moving bus stops suddenly due to inertia of motion.

121. What is a normal reaction force ? Draw a neat la-belled diagram showing a normal reaction force acting on a body.

Ans :
The normal reaction force is a contact force that acts perpendicular to the surface of contact between two objects. When an object is placed on a surface, it exerts a force on the surface due to its weight. According to Newton's third law, the surface exerts an equal and opposite force on the object, which is the normal reaction force.



122. 'More the mass, more difficult it is to move the body from rest'. Explain this statement by giving an example.

Ans :
More the mass, more difficult it is to move the body from rest. This is because of inertia. Inertia is the tendency of an object to resist any change in its state of rest. Mass is the measure of inertia — greater the mass, greater the inertia. For example, consider a bicycle and a car, both standing at rest on a road. When you push the bicycle, it starts moving easily because it has less mass and less inertia. But when you push the car, it is very difficult to move it because it has more mass and more inertia. This means the car resists being moved from rest much more strongly than the bicycle. Therefore, more the mass of a body, more is its inertia, and more difficult it is to move it from its state of rest.

123. Classify the following amongst the contact and non-contact forces :
(a) Frictional force,
(b) Normal reaction force,
(c) Force of tension in a string,
(d) Gravitational force,
(e) Electrostatic force,
(f) Magnetic force.

Ans :
Contact forces :
(a) Frictional force,
(b) Normal reaction force and
(c) Force of tension in a string.
Non-contact forces :
(d) Gravitational force
(e) Electrostatic force
(f) Magnetic force

124. How can Newton's first law of motion be obtained from the second law of motion?

Ans :
According to Newton's second law of motion

$$F = ma$$

If $F = 0$

Then $\mathrm{ma} = 0$

$$\mathrm{a} = 0 \ (m \neq 0)$$

This means that if no external force is applied on the body, then its acceleration will be zero. Therefore, a body at rest will remain at rest and a body in motion will go on moving with the same speed in the same direction. In other words, a body not acted upon by any external force, has an unaccelerated motion. This is the statement of Newton's first law of motion. Thus Newton's first law of motion can be obtained from the second law.

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125. Distinguish between mass and weight.

Ans :
The difference between the mass and weight are as follows :

	Mass	**Weight**
(i)	It is the quantity of matter contained in a body.	It is the force with which a body is attracted towards the centre of the earth.
(ii)	It is constant quantity.	$W = m \times g$, hence its value changes to the value of 'g'.
(iii)	It is a scalar quantity.	It is a vector quantity.
(iv)	Its unit is kg.	its unit is 'newton'.
(v)	Beam balance is measure it.	Spring balance is used to used to measure it.
(vi)	At no place its value is zero	At the centre of earth its value is zero.

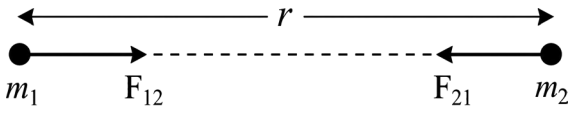
126. Why does a glass vessel break when it falls on a hard floor, but it does not break when it falls on a carpet?

Ans :
When a glass vessel falls on a hard floor, the vessel comes to rest in a very short time. Due to this, the rate of change of momentum is very large, and therefore a very large force acts on the vessel. This large force causes the glass vessel to break.
But when the same glass vessel falls on a carpet, the carpet being soft increases the time taken by the vessel to come to rest. Due to this, the rate of change of momentum is very small, and therefore only a small force acts on the vessel. This small force is not enough to break the glass vessel, and so it remains safe.

This is based on Newton's Second Law of Motion, which states that force is directly proportional to the rate of change of momentum. More the time taken to stop, less is the force, and less the time taken to stop, more is the force.

127. State Newton's law of gravitation.

Ans :
This law states that the force of attraction acting between two particles is directly proportional to the product of their masses and inversely proportional to the square of the distance between them'



i.e. $F \propto m_1 m_2$

And $F \propto \frac{1}{r^2}$

Combining (i) and (ii), we have

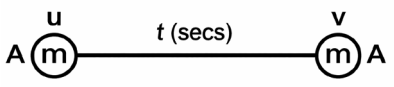
$$F \propto \frac{m_1 m_2}{r^2}$$

or $$F = \frac{G\, m_1 m_2}{r^2}$$

Where G is the constant of proportionality and is known as the universal gravitational constant. Its value at all places in this universe is 6.67×10^{-11} $Nm^2\, kg^{-2}$

128. Show that,
Rate of change of momentum
= mass × acceleration.
Under what condition does this relation hold ?

Ans :
Consider a body of mass (m), on application of force for time t changes its velocity u at A to velocity v at B.



Momentum of boy $A = mu$

After t secs. momentum at $B = mv$
Change in momentum in t (secs.)

$$= mv - mu$$
$$= m(v - u)$$

Rate of change of momentum $= \frac{m(v-u)}{t}$

$= m \times$ rate of change of velocity

But rate of change of velocity= acceleration (a)

Rate of change of momentum $= m \times a$

Rate of change of momentum = mass × acceleration.
The relation holds when mass of the body remains constant.

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FOUR MARKS QUESTIONS

129. Two bodies A and B, of same mass are moving with velocities v and $2v$ respectively. Compare their (i) inertia, (ii) momentum.

Ans :

Body A	Body B
Mass $= m$	mass $= m$
Velocity $= v$	velocity $= v$

(i) $\frac{\text{Inertia of body } A}{\text{Inertia of body } B} = \frac{m}{m} = \frac{1}{1} = 1:1$

Inertia of body depends upon the mass of body.

(ii) Momentum of body

A = mass $\times$ velocity $\quad$ B = mass $\times$ velocity

$= m \times v \quad$ $= m \times 2v$

Momentum of A : Momentum of $B = 1 : 2$

If change in velocity alone takes place and mass remains constant then

130. State and explain the law of action and reaction by giving two examples.

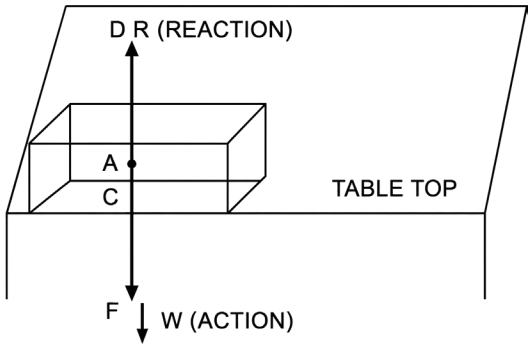
Ans :

Statement "Action and reaction are always equal and opposite in direction."

Action and reaction do not act on the same body, but they always act simultaneously on two different bodies. Action and reaction do not cancel each other.

Example:

(1) Consider a book lying on the table. Its weight (w) acts vertically downward (Action on the table) and book does not fall. That means table is exerting equal force on the book, but in opposite direction [normal reaction R] called reaction. Thus, action and reaction are equal and opposite.



Action and reaction on a book lying on a table

(2) When we swim in water, we push the water backward (Action) and water in turn exerts equal force on us but in opposite direction (Reaction) i.e. there are two different objects man and water and two forces equal in magnitude and opposite in direction.

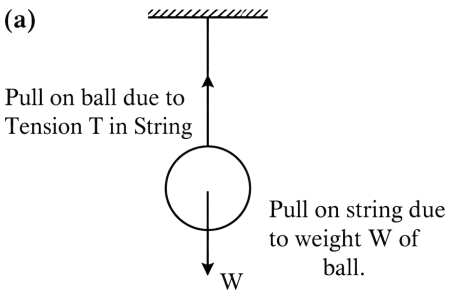
131. (a) A ball is hanging by a string from the ceiling of the roof. Draw a neat labelled diagram showing the forces acting on the ball and the string.

(b) A spring is compressed against a rigid wall. Draw a neat and labelled diagram showing the forces acting on the spring.

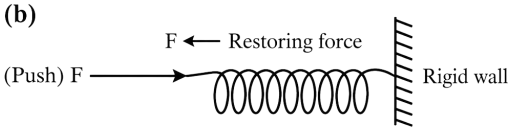
(c) A wooden block is placed on a table top. Name the forces acting on the block and draw a neat and labelled diagram to show the point of application and direction of these forces.

Ans :

(a)

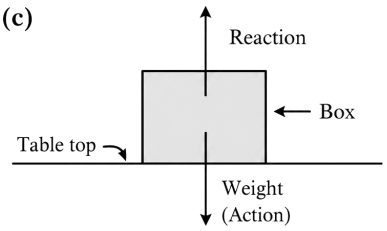


(b)



Forces acting on a spring when compressed against a rigid wall

(c)



132. A body of mass m moving with a velocity v is acted upon by a force. Write expression for change in momentum in each of the following cases :

(i) When $v << c$

(ii) When $v \to c$ and

(iii) When $v << c$ but m does not remain constant.

Here c is the speed of light.

Ans :

We know that

Change in momentum $\Delta p = \Delta (mv)$ The change in product mv can be either due to change in mass (m) or due to change in velocity (v) or due to both mass and velocity. $\Delta p = \Delta (mv)$ ...(a)

It is observed that if velocity of body i.e. atomic particle is comparable to the velocity of light $c(= 3 \times 10^8\ \text{ms}^{-1})$ then the mass of the particle does not remian constant, but it increases with increases in velocity according to relation

$$m = \frac{m_0}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$$

Where m_0 is the mass of the particle when it is at rest (i.e. $v = 0$) then we cannot write $\Delta (mv) = m \Delta v$

(i) When $v << c$ i.e. when velocity of particle is much smaller than velocity of light c. The relation $\Delta p = m \Delta v$ is true.
It is when the velocity of particle is of the order of 10^6 ms^{-1} or less than it, the variation in mass with velocity is not very perceptible and mass can be treated to be constant

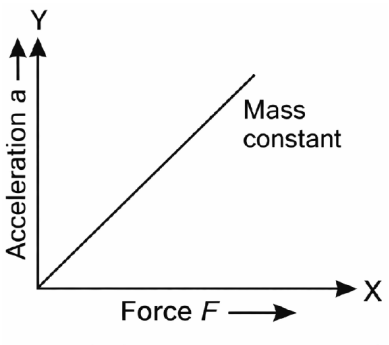
(ii) When $v \to c$
When velocity v is comparable to speed of light
Then $\Delta p = \Delta (mv)$

(iii) When $v << c$ but m does not remain constant
Then $\Delta p = \Delta (mv)$

133. Draw graphs to show the dependence of
(i) Acceleration on force for a constant mass, and
(ii) Force on mass for a constant acceleration.

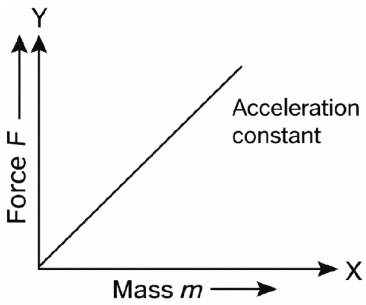
Ans :

(i) Mass remaining constant, variation of acceleration with force.



Graph showing the variation of acceleration with force

(ii) Acceleration constant, variation of force with mass.



Graph showing the variation of force with mass

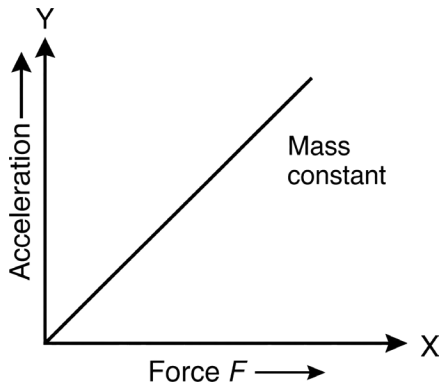
134. How does acceleration vary with the force applied for a given body? Show it with the help of a graph.

Ans :

According to Newton's second law of motion, the acceleration of an object is directly proportional to the force applied to it, and inversely proportional to its mass. This can be expressed mathematically as:

$$a = F/m$$

Where, a is the acceleration of the object, F is the force applied to it, and m is the mass of the object. To show how acceleration varies with the force applied for a given body, we can plot a graph of acceleration versus force, keeping the mass of the object constant. Here's a graph that shows the relationship between acceleration and force for a given body:



The graph shows that acceleration is directly proportional to force. As the force applied to the object increases its acceleration also increases, and vice versa. The slope of the graph represents the constant of proportionality between force and acceleration, which is equal to 1/m. Therefore, the steeper the slope of the graph, the smaller the mass of the object.

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135. Explain the following :

(a) When a train suddenly moves forward, the passenger standing in the compartment tends to fall backwards.

(b) When a corridor train suddenly starts, the sliding doors of some compartments may open.

(c) After alighting from a moving bus, one has to run for some distance in the direction of bus in order to avoid falling.

(d) Dust particles are removed from a carpet by beating it.

(e) It is advantageous to run before taking a long jump.

Ans :

(a) When the train is at rest, passengers standing in the compartment are also at rest. When train suddenly moves forward, the passenger tends to fall backward as upper part of his body continues to be in state of rest due to moment of inertia while lower part of his body comes in motion.

(b) Due to inertia of rest, the sliding door of compartment opens or closes when train suddenly starts and due to inertia of motion, the sliding door of the compartment opens or closes when train suddenly stops.

(c) One has to run for some distance in the direction of bus in order to avoid falling, otherwise the feet will suddenly come to rest while upper part of his body being in motion, because of inertia of motion he may fall down and get injured.

(d) On beating the carpet, carpet come in motion while dust particle due to inertia of rest fall and are removed.

(e) To run before jumping brings one in state of motion and then it becomes easier to take a - jump.

136. Two balls A and B, of masses m and 2 m arc in motion with velocities 2 v and v respectively. Compare

(i) Their inertia,

(ii) Their momentum, and

(iii) The force needed to stop them in the same time.

Ans :

Ball A	Ball B
Mass $= m$	Mass $= 2m$
Velocity $= 2v$	Velocity $= v$

(i) $\dfrac{\text{Inertia of body } A}{\text{Inertia of body } B} = \dfrac{m}{2m} = \dfrac{1}{2}$

Ratio of inertia of Ball A : inertia of Ball B $= 1 : 2$

Since inertia depends upon mass of body.

(ii) $\dfrac{\text{Momentum of } A}{\text{Momentum of } B} = \dfrac{m \times 2v}{2m \times v} = \dfrac{1}{1}$

Ratio of inertia of Ball A : inertia of Ball B $= 1 : 1$

Since inertia depends upon mass of body.

(iii) Acceleration of $A = \dfrac{\text{velocity}}{\text{time}} = \dfrac{2v}{t} = a_1$

Acceleration of $B = \dfrac{\text{velocity}}{\text{time}} = \dfrac{v}{t} = a_2$

$$\frac{\text{Force needed to stop } A}{\text{Force needed to stop } B} = \frac{m.a_1}{m.a_2}$$

$$= \frac{m\frac{2v}{t}}{2m\frac{v}{t}} = 1{:}1$$

$$\frac{\text{Force on } A}{\text{Force on } B} = \frac{1}{1}$$

Ratio of force on A to force $B = 1 : 1$

137. State Newton's second law of motion. Under what condition does it take the form F = ma ?

Ans :

Newton's second law of motion states that rate of change of momentum is directly proportional to force applied and takes place in the direction of force'

Derivation of F = ma from Newton's second Law of Motion :

Newton introduced the concept of momentum and say "The momentum of a moving body is defined as the product of its mass and velocity"

Thus, $p = mu,$

Where $p =$ momentum of body

$m =$ mass of body

$u =$ velocity of body

Suppose the velocity of body of mass m changes from u to v, in time t.

initial momentum, $p_1 = mu$

and final momentum, $p_2 = mv$

The change in momentum, $(p_2 - p_1)$ takes place in time t. Then according to Newton's second law of motion, the magnitude of force F is

$$\frac{p_2 - p_1}{t} \in F,$$

or $$F = \frac{km(v-u)}{t}$$

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Where k = constant of proportionality.

Now, $a\frac{(v-u)}{t}$, where a = acceleration of body

$$F = kma$$

$$F = kma \qquad (k = 1, \text{constant})$$

This relation holds good when mass of the body remains constant.

138. Use Newton's second law of motion to explain the following :-

(a) A cricketer pulls his hands back while catching a fast moving cricket ball'

(b) An athlete prefers to land on sand instead of hard floor while taking a high jump.

Ans :

(a) Let m be the mass of cricket ball moving with a velocity u before catching it'
Initial momentum = mu
When cricketer stops the ball $v = 0$
So, final momentum= $m \times 0 = 0$
If the cricketer does not withdraw his hands, then the force exerted by ball on hand of Cricketer, $F_1 = \frac{0 - mu}{t_1} = \frac{-mu}{t_1}$

But if the cricketer withdraws his hands it takes longer time t_2 to stop the ball. The force exerted by ball on his hand, $F_2 = \frac{-mu}{t_2}$. So, $t_2 > t_1$, hence $F_2 < F_1$

Force exerted on the hand of the cricketer is less when he withdraws his hands. Thus, the cricketer avoids the chances of injury to his hands by withdrawing his hands while catching a ball.

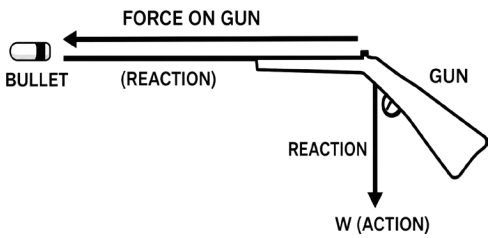
(b) If an athlete jumps from a height on a hard floor, he may hurt his feet because his feet comes to rest in very short time so a very large force is exerted on his feet. On the other hand, by jumping on sand or foam, the time duration in which his feet come to rest increases so the force exerted on his feet decreases and he is saved from getting hurt.

139. Name and state the action and reaction in the following cases:

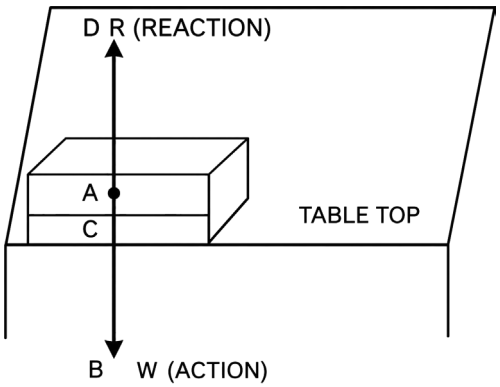
(a) Firing of a bullet from a gun,
(b) Hammering a nail,
(c) A book lying on a table,
(d) A moving rocket,
(e) A person walking on the floor, and
(f) A moving train colliding with a stationary train.

Ans :

(a) Firing of a bullet from a gun. When a bullet is fired from a gun the force acting on bullet in the forward direction is action and the force acting on the gun in backward direction is reaction.

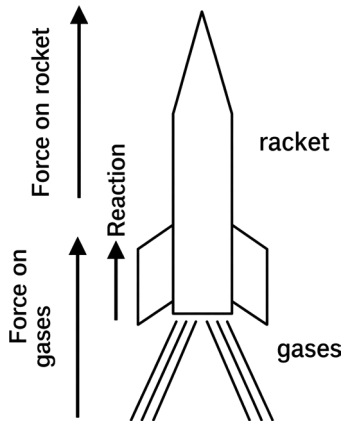


(b) Hammering a nail : Force acting on nail due to hammer is action and force acting on hammer due to nail is reaction.



Action and reaction on a book lying on a table

(c) A book lying on a table: Weight (force) of book acting vertically downward on table is action and normal reaction on book due to table is reaction.



(d) A person walking on the floor. The foot pushing the floor backward in action. Floor gives a push to the foot in forward direction is reaction.

(e) A person walking on the floor. The foot pushing the floor backward is action. Floor gives a push to the foot in forward direction is reaction.

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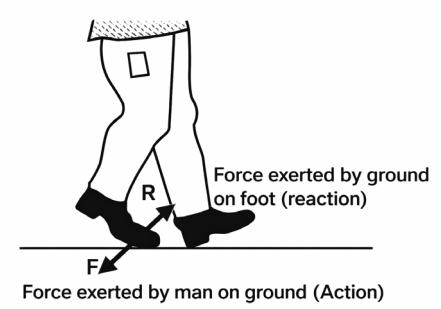

NUMERICAL QUESTIONS

140. A force of 15 N acts on a body of mass 2 kg. Calculate the acceleration produced.

Ans :

Here, $F = 15\,\text{N}$,

Mass $m = 2\,\text{kg}$

$$a = \frac{F}{m} = \frac{15}{2} = 7.5$$

$$a = 7.5\,\text{ms}^{-2}$$

141. A force of 10 N acts on a body of mass 5 kg. Find the acceleration produced.

Ans :

Here, $F = 10\,\text{N}$,

Mass $m = 5\,\text{kg}$

$$a = \frac{F}{m} = \frac{10}{2} = 2\,\text{ms}^{-2}$$

$$a = 2\,\text{ms}^{-2}$$

142. Calculate the magnitude of force which when applied on a body of mass 0.5 kg produces an acceleration of 5 ms^{-2}.

Ans :

Given, $m = 0.5\,\text{kg}$

$a = 5\,\text{ms}^{-2}$

$F = ma$

$= 0.5 \times 5 = 2.5\,\text{N}$

143. A body of mass 5 kg is moving with velocity 2 ms^{-1} Calculate its linear momentum.

Ans :

Here; $m = 5$ kg;

$v = 2\ \text{m s}^{-1}$

Let linear momentum of the body = p = ?

Using $p = mv$, we have

$p = 5 \times 2\ \text{kg ms}^{-1}$

$= 10\ \text{kg ms}^{-1}$

144. A man weighs 600 N on earth. What would be his approximate weight on moon ? Give reason for your answer ?

Ans :

Weight of man on earth = 600 N

The value of g on the moon is $\frac{1}{6}$th of its value on surface of the earth. Therefore, the weight of the man on the moon will be $\frac{1}{6}$th of his weight of the Earth $= \frac{1}{6} \times 600\,\text{N} = 100\,\text{N}$

145. Calculate the weight of a body of mass 10 kg in (a) kgf and (b) newton. Take g = 9.8 m s^{-2}

Ans :

Here ; m=10 kg

(a)Weight of the body= 10 kgf

(b)Weight of the body= mg

$= 10 \times 9.8$

N= 98 N

146. State the magnitude and direction of the force of gravity acting on a body of mass 5 kg. Take g = 9.8 ms^{-2}

Ans :

Magnitude of force of gravity acting on the body = 98 N

Direction of force of gravity is downwards.

Here m= 5 kg

Direction of force of gravity in downwards

=5 × 9.8 = 49 N

147. The weight of a body is 2.0 N. What is the mass of the body? (g =10 m s^{-2})

Ans :

Here; $W = 2.0$ N

g = 10 m s^{-2}

m = ?

$$m = \frac{W}{g}$$

$$= \frac{2}{10}\,\text{kg}$$

$$= 0.2\,\text{kg}$$

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148. What is the (a) force of gravity and (b) weight of a block of mass of 10.5 kg ? Take g = 10 ms^{-2}.

Ans :

Here; $m = 10.5$ kg, g = 10 ms^{-2}

(a) Force with which the mass is being pulled by the earth

$= mg$

$= 10.5 \times 10$ N $= 105$ N

(b) Weight $= mg$

$= 10.5 \times 10$ N $= 105$ N

149. What force, in newton, your muscles need to apply to hold a mass of 5 kg in your hand ? State the assumption.

Ans :

Mass = 5 kg

1 Kgf = 9.8 N = force on 1 kg mass

To hold 1 kg mass, force needed = 9.8 N kg^{-1}

To hold mass of 5 kg, force

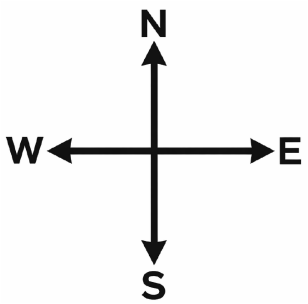
$= 5 \times 9.8$ N $= 49$ N

(Assumption : g = 9.8 N kg^{-1})

150. A boy pushes a wall with a force of 10N towards east. What force is exerted by the wall on the boy ?

Ans :

As the boy pushes a wall with a force of 10N towards east, so the force exerted by wall on the boy is 10N toward west.



151. Write the approximate weight of a body of mass 5 kg. What assumption have you made ?

Ans :

$m = 5$ kg

g $= 9.8\ ms^{-2}$

$= 10\ ms^{-2}$

$W = ?$

Using $W = mg$, we have

$W = 5 \times 10N = 50\ N$

Assumption : g $= 10\ ms^{-2}$

152. A body is dropped from the top of a tower. It acquires a velocity 20 ms^{-1} on reaching the ground. Calculate the height of the tower. (Take g = 10 ms^{-2})

Ans :

Here, $u = 0$ [as the body falls downward]

g $= 10\ ms^{-2}$

$v = 20\ ms^{-1}$

$u = ?$

Using, $2gh = v^2 - u^2$

$2 \times 10 \times h = (20)^2 - (0)^2$

$h = \frac{400}{20} = 20$

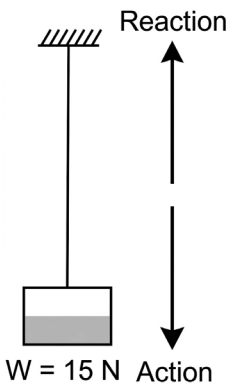
Height of tower $h = 20$ m

153. Name them and show them in the diagram.

Ans :

(a) As the weight of box is heavy, so it is exerting a downward (weight) force of 15N.

(b) And the force exerted by string on the block is 15N upwards (tension).



154. The linear momentum of a ball of mass 50 g is 0.5 kg ms^{-1}. Find its velocity.

Ans :

Here; $p = 0.5$ kg ms^{-1}

$m = 50\ g$

$= \frac{50}{1000}$ kg

$= \frac{1}{20}$ kg

$v = ?$

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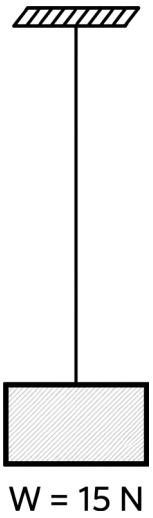
Using $p = mv$, we get

$$v = \frac{p}{m}$$

$$= \frac{0.5}{\frac{1}{20}} \text{ms}^{-1}$$

$$= 10 \text{ ms}^{-1}$$

155. In figure, a block of weight 15N is hanging from a rigid support by a string. What force is exerted by



(a) block on the string.

(b) String on the block.

156. The force of attraction between the two bodies at a certain separation is 10 N. What will be the force of attraction between them if the separation between them is reduced to half ?

Ans :

Let the separation be r

$$F_1 = 10\ N$$

$$F_1 = \frac{G\, m_2 m_2}{r^2} \quad \text{...(i)}$$

Now $F_2 = ?$

$$r_2 = \frac{r}{2}$$

$$F_2 = \frac{G\, m_1 m_2}{\left(\frac{r}{2}\right)^2}$$

$$F_2 = 4 = \frac{G\, m_1 m_2}{r^2} \quad [\text{ From (i)}]$$

$$F_2 = 4 \times 10$$

$$= 40\ N$$

157. A body of mass 500 g, initially at rest, is acted upon by a force which causes it to move a distance of 4 m in 2 s. Calculate the force applied.

Ans :

Given, $m = 500\ g$ or 0.5 kg

$v = 4$ m

$t = 2$ s

$u = 0$

Now,

$$\text{Acceleration (a)} = \frac{\text{Change in velocity}}{\text{Time}}$$

$$a = \frac{v - u}{t}$$

$$= \frac{(4-0)\text{ m}}{2\text{ s}}$$

$$= 2 \text{ ms}^{-1}$$

From the relation $F = ma$,

Force $F = 0.5 \times 2$

$$= 1 \text{ N}$$

158. A force of 10 N acts on a body of mass 2 kg for 3 s, initially at rest. Calculate : (i) the velocity acquired by the body and (ii) change in momentum of the body.

Ans :

Here, $F = 10$ N

$u = 0$

$m = 2$ kg

$t = 3$ sec

(i) $F = ma$

$$a = \frac{F}{m}$$

$$= \frac{10}{2} = 5 \text{ ms}^{-2}$$

Now $v = u + at$

$$v = 0 + 5 \times 3 = 15$$

$$v = 15 \text{ ms}^{-1}$$

(ii) Change in momentum is given by

$$= mv - mu$$

$$= m(v - u)$$

$$= 2(15 - 0) = 30$$

Change in momentum

$$= 30 \text{ kg ms}^{-1}$$

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159. A force causes an acceleration of 10 ms^{-2} in a body of mass 500g. What acceleration will be caused by the same force in a body of mass 5 kg ?

Ans :

We know, that $F\ m \times a$,

where F = force acting on a body,

m = mass of body and

a = acceleration

Now, Force F_1 causes acceleration

$$a_1 = 10\ ms^{-2}$$

on a body of mass $m_1 = 500\ g = 0.5\ kg$

Thus, $F_1 = m_1 \times a_1$ ...(i)

Now, force F_2 causes acceleration a_2 = ? on a body of mass $m_2 = 5\ kg$

Thus, $F_2 = m_2 \times a_2$ ...(ii)

From eqn. (i) and (ii),

$$m_1 \times a_1 = m_2 \times a_2 \quad (F_1 = F_2)$$
$$= 0.5 \times 10$$
$$= 5 \times a_2$$
$$a_2 = \frac{0.5 \times 10}{5}$$
$$= 1\ ms^{-2}$$

160. The weight of a body on earth is 98 N where acceleration due to gravity is 9.8 ms^{-2}. What will be its (a) mass and (b) weight on the moon where the acceleration due to gravity is 1.6 ms^{-2} ?

Ans :

Here;

$$W = 98\ N$$

(a) $g = 9.8\ ms^{-2}$

m = ?

Using $W = mg$,

We have $98 = m \times 9.8$

$$m = \frac{98}{9.8}\ kg = 10\ kg$$

(b) $g = 1.6\ ms^{-2}$

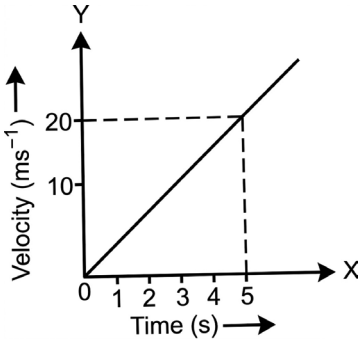
W = ?

Using $W = mg$,

We have $W = 10 \times 1.6\ N$

$$m = \frac{98}{9.8}\ kg$$
$$= 16\ N$$

161. Figure shows the velocity - time graph of a particle of mass 100 g moving in a straight line. Calculate the force acting on the particle.



Ans :

Given, velocity $= 20\ ms^{-1}$

and time, $t = 5\ sec$

So, acceleration $= \frac{(v-u)}{t}$

$$= \frac{20-0}{5} = 4\ ms^{-2}$$

Now, mass of body $= 100\ g$

$$= \frac{1}{10}\ kg.$$

So, force $= m \times a$

$$= \frac{1}{10} \times 4 = 0.4\ N$$

The acceleration caused by the force in a body of mass 5 kg $= 1\ ms^{-2}$

162. A pebble is thrown vertically upwards with a speed of 20 ms^{-1}. How high will it be after 2 s ? (Take g = 10 ms^{-2})

Ans :

Here, body is thrown upward

g $-10\ ms^{-2}$

u $20\ ms^{-1}$

$t = 2s$,

h = ?

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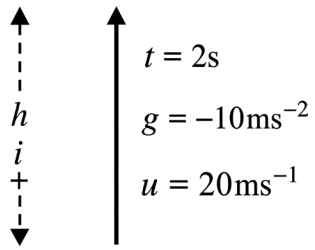


$$h = ut + \frac{1}{2}gt^2$$

$$h = (20 \times 2) + \frac{1}{2}(-10) \times (2 \times 2)$$
$$= 40 - 20 = 20$$
$$h = 20\,\text{m}$$

163. A cricket ball of mass 150 g moving at a speed of 25 ms^{-1} is brought to rest by a player in 0.03 s. Find the average force applied by the player.

Ans :

Given, $u = 25\,\text{ms}^{-1}$

$$t = 0.03 = \frac{3}{100}\,\text{sec}$$

From the first equation of the motion ,we get

$$v = u + at$$
$$0 = 25 + a\frac{3}{100}$$
$$a = -25 \times \frac{100}{3}$$
$$= -2500\,\text{ms}^{-2}$$

Now $m = 150$

$$= \frac{150}{1000} = \frac{3}{20}\,\text{kg}$$
$$F = ma$$
$$= \frac{3}{20} \times \frac{-2500}{3} = -125\,\text{N}$$

164. A force acts for 10 s on a stationary body of mass 100 kg after which the force ceases to act. The body moves through a distance of 100 m in the next 5 s' Calculate :
(i) the velocity acquired by the body,
(ii) the acceleration produced by the force, and
(iii) the magnitude of the force.

Ans :

(i) Distance travelled,

$$s = 100\,\text{m}$$
$$t = 5\,\text{sec}$$
$$v = \frac{\text{distance}}{\text{time}} = \frac{100}{5} = 20\,\text{ms}^{-1}$$

(ii) $a = ?$

$$u = 0$$
$$t = 10\,\text{sec}$$
$$v = 20\,\text{ms}^{-1}$$
$$v = u + at$$
$$20 = 0 + a \times 10$$

or $a = 20$

(iii) $F = ma$

$$= 100 \times 2$$
$$= 200\,\text{N}$$

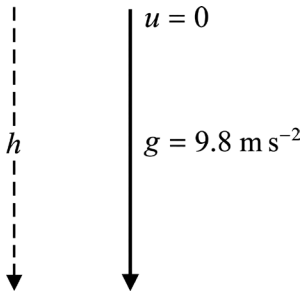
165. A body falls from the top of a building and reaches the ground 2.5 s later. How high is the building ? (Take g = 9.8 ms^{-2})

Ans :

Here

Initial vel $u = 0$,

$g = 9.8\,\text{ms}^{-2}$,



$t = 2.5s$,

Using $h = \frac{1}{2}gt^2$

$$h = \frac{1}{2} \times 9.8 \times 2.5 \times 2.5$$
$$= 30.625\,\text{m}$$

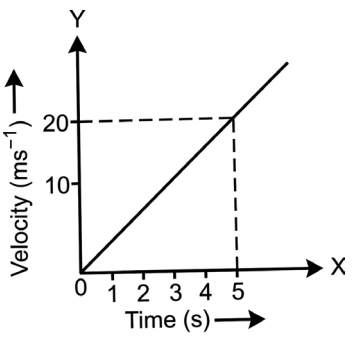
Height of the building $h = 30.625\,\text{m}$

166. A force acts for 0.1 s on a body of mass 2.0 kg initially at rest. The force is then withdrawn and the body moves with a velocity of 2 ms 1. Find the magnitude of the force.

Ans :

Here $v = 2\,\text{ms}^{-1}$

$u = 0$



$t = 0.1 = \frac{1}{10}\text{sec}$

$a = ?$

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From the first equation of the motion ,we get

$$v = u + at$$
$$2 = 0 + \frac{1}{10}a$$
$$a = 20\ \text{ms}^{-2}$$
$$F = ma$$
$$= 2 \times 20 = 40$$
$$F = 40\ \text{N}$$

167. A car of mass 480 kg moving at a speed of 54 km h^{-1}, is stopped by applying breaks in 10 s. Calculate the force applied by the brakes.

Ans :

Here
$$v = 0$$
$$u = 54\ \text{km h}^{-1}$$
$$= 54 \times \frac{5}{18} = 15\ \text{ms}^{-1}$$
$$t = 10\ \text{sec}$$

From the first equation of the motion, we get

$$v = u + at$$
$$0 = 15 + a \times 10$$
$$a = \frac{-15}{10}$$
$$= \frac{-3}{2}\ \text{ms}^{-2}$$

Now,
$$m = 480\ \text{kg}$$
$$a = \frac{3}{2}\ \text{ms}^{-2}$$
$$F = ma$$
$$= 480 \times \frac{3}{2}$$
$$= 720\ \text{N}$$

168. A car is moving with a uniform velocity 30 m s^{-1}. It is stopped in 2 s by applying a force of 1500 N through its brakes. Calculate :
(a) the change in momentum of car,
(b) the retardation produced in car, and
(c) the mass of car.

Ans :

Here;
$$u = 30\ \text{ms}^{-1}$$
$$v = 0;$$
$$t = 2s$$
$$F = 1500\ \text{N}$$

(a) Change in momentum of the car
$$= F \times t$$
$$= 1500 \times 2$$
$$= 3000\ \text{kg ms}^{-1}$$

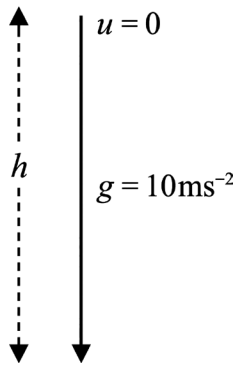
(b) Using $v = u + at$, we get
$$0 = 30 + a \times 2$$
or
$$2a = -30$$
$$a = -15\ \text{ms}^{-2}$$
i.e. Retardation $= 15\ \text{ms}^{-2}$

(iii) Using $F = ma$, we get
$$m = \frac{F}{a}$$
$$= \frac{1500}{15}\ \text{kg}$$
$$= 100\ \text{kg}$$

169. A stone is dropped freely from the top of a tower and it reaches the ground in 4 s. Taking g =10 ms^{-2}, calculate the height of the tower.

Ans :

Here
$$u = 0,$$
$$t = 4\ \text{sec},$$
$$\text{g} = 10\ \text{ms}^{-2},$$
$$h = ?$$



Using
$$h = ut + \frac{1}{2}gt^2$$
$$h = (0 \times 4) + \frac{1}{2} \times 10 \times (4 \times 4)$$
$$= 0 + 80$$
$$h = 80\ \text{m}$$
Height of tower $= 80\ \text{m}$

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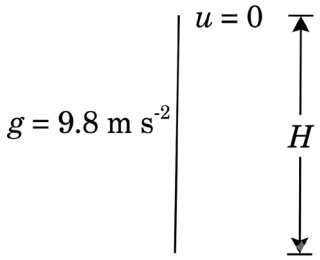
170. A ball is released from a height and it reaches the ground in 3 s. If g = 9.8 ms^{-2}, find :
(a) the height from which the ball was released,
(b) the velocity with which the ball will strike the ground.

Ans :
As the ball is falling down

$u = 0$
$H = ?$
$g = 9.8\ ms^{-2}$
$t = 3\ s$



(a) $H = \frac{1}{2}gt^2$

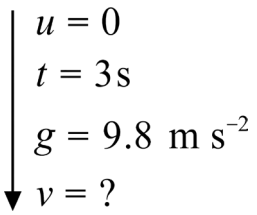
$H = \frac{1}{2} \times 9.8 \times 3 \times 3$

$H = 44.1\ m$

(b) $v = u + gt$

$v = 0 + 9.8 \times 3$

$v = 29.4\ ms^{-1}$



171. A bullet of mass 50 g moving with an initial velocity 100 ms^{-1}, strikes a wooden block and comes to rest after penetrating a distance 2 cm in it. Calculate :-
(i) Initial momentum of the bullet.
(ii) Final momentum of the bullet.
(iii) Retardation caused by the wooden block, and
(iv) Resistive force exerted by the wooden block.

Ans :
Here, Mass of bullet,

$m = 50\ g = 0.05\ kg$

(i) Initial momentum of bullet

= mass × initial velocity

$= 0.05 \times 100 = 5\ kg\ ms^{-1}$

(ii) Final momentum of bullet

= mass × final velocity

$= 0.05 \times 0 = 0$ or zero

(iii) Retardation caused by wooden block is the negative acceleration

Distance, $d = 2\ cm$

$= 0.02\ m$

$\text{Time} = \frac{\text{distance}}{\text{speed}}$

$= \frac{0.02}{\frac{100+0}{2}} = \frac{0.02}{50}$

$\left[\text{Av. speed} = \frac{u+v}{0}\right]$

$\text{Time} = \frac{2}{5 \times 10^3}$

Now, acceleration, $a = \frac{(v-u)}{t}$

$= \frac{(0-100) \times 5 \times 10^3}{2}\ ms^{-2}$

$= \frac{-5}{2} \times 10^5\ ms^{-2}$

$= -2.5 \times 10^5\ ms^{-2}$

So, retardation $= 2.5 \times 10^5\ ms^{-2}$

(iv) Resistive force, $F = m \times a$

mass of bullet, $m = 50\ g = 0.05\ kg$

So, $F = 0.05 \times 2.5 \times 10^5$

$= \frac{25 \times 5}{1000} \times 10^5\ N$

$= 12500\ N$

172. A ball is thrown vertically upwards. It goes to a height 20 m and then returns to the ground. Taking acceleration due to gravity g to be 10 ms^{-2}, find:
(a) The initial velocity of the ball
(b) The final velocity of the ball on reaching the ground and
(c) The total time of journey of ball

Ans :
(a) For ball thrown upward

$v = 0$
$u = ?$
$h = 20\ m$

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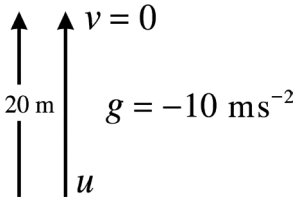
$$g = -10\ ms^{-2}$$
$$2gh = v^2 - u^2$$
$$2 \times (-10) \times 20 = (0)^2 - u^2$$
$$-u^2 = -400$$
$$u^2 = 400 = (20)^2$$
$$u = 20\ ms^{-1}$$

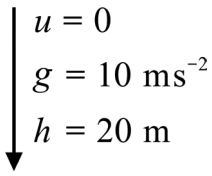


(b) Velocity on reaching the ground is equal to velocity with which it was thrown up

$$v = u$$
$$= 10\ ms^{-1}$$

For ball when dropped

$$u = 0$$
$$v = ?$$
$$g = 10\ ms^{-2}$$
$$h = 20\ m$$
$$v^2 - u^2 = 2\,gh$$
$$v^2 - 0 = 2 \times 10 \times 20$$
$$= 400$$
$$v^2 = (20)^2$$
$$v = 20\ ms^{-1}$$



(c) For ball when dropped

$$v = 0$$
$$t = ?$$
$$h = 20\ m$$
$$h = \frac{1}{2}gt^2$$
$$20 = \frac{1}{2} \times 10t^2$$
$$t^2 = 4 = (2)^2$$
$$t = 2\ sec.$$

As time of ascent = time of descent

Total time of journey= 2 + 2 = 4 sec.

173. A ball is thrown vertically upwards. It returns 6 s later. Calculate : (i) the greatest height reached by the ball and (ii) the initial velocity of the ball. (Take g = 10 ms^{-2})

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Ans :

Since time of ascent is always equal to the time of descent

Time taken for downward motion

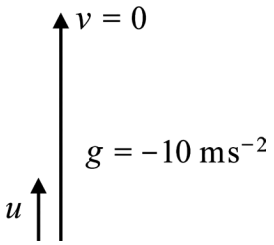
$$t = \frac{6}{2} = 3\ sec.$$
$$t = 3s$$
$$h = ?$$
$$g = 10\ ms^{-2}$$
$$u = 0$$

(i) $$h = \frac{1}{2}gt^2$$
$$= \frac{1}{2} \times 10 \times 3 \times 3 = 45$$

Greatest height reached $h = 45$ m

(ii) For upward motion at maximum height reached

$$v = 0$$
$$v = u + gt$$
$$0 = u - 10 \times 3$$
$$u = 30\ ms^{-1}$$



174. (a) How long will a stone take to fall to the ground from the top of a building 80 m high and

(b) what will be the velocity of the stone on reaching the ground ? (Take g =10 ms^{-2})

Ans :

(a) As stone falls down

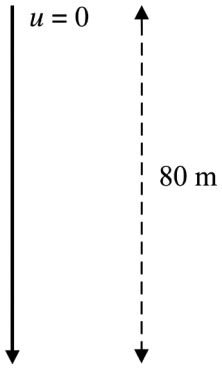
Initial vel. $u = 0$,

$t = ?$

$h = 80$ m,

$g = 10\ ms^{-2}$

Using $s = \frac{1}{2}gt^2$



$$h = 80$$
$$= \frac{1}{2} \times 10t^2$$
$$t^2 = 16$$
$$t = 16$$
$$t = \sqrt{16} = 4s$$

(b) To final velocity v on reaching the ground

$$v^2 - u^2 = 2gh$$
$$v^2 - (0)^2 = 2 \times 10 \times 80 = 1600$$
$$v = 40 \text{ ms}^{-1}$$

175. A ball is thrown vertically upwards with an initial velocity of 49 ms^{-1}. Calculate : (i) the maximum height attained, (ii) the time taken by it before it reaches the ground again. (Take g = 9.8 ms-^{2})

Ans :

For a body thrown vertically upward

. $v = 0$,

$g = -9.8 \text{ ms}^{-2}$,

$u = 49 \text{ ms}^{-1}$

$t = ?$

Using, $v = u + gt$

$0 = 49 - 9.8\,t$

$t = 5s$

It will also take $t = 5s$ to come back.

(i) Total time taken

$$= 5 + 5 = 10s$$

(ii) and while falling down

$u = 0$

$t = 5s$

$g = -9.8 \text{ ms}^{-2}$,

$h = ?$

$$h = ut + \frac{1}{2}gt^2$$
$$h = 0 + \frac{1}{2} \times 9.8 \times 5 \times 5$$
$$h = 122.5 \text{ m}$$

Maximum height attained $h = 122.5$ m

176. A pebble is droped freely in a well from its top. It takes 20 s for the pebble to reach the water surface in the well. Taking g = 10 ms^{-2} and speed of sound = 330 ms^{-1}, find :

(i) the depth of water surface,and

(ii) the time when echo is heard after the pebble is dropped.

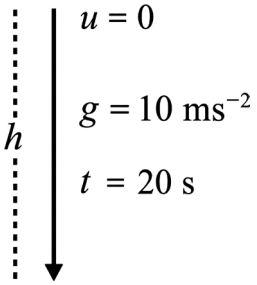
Ans :

(i) Depth of wall $h = \frac{1}{2}gt^2$

$$h = \frac{1}{2} \times 10 \times (20)^2$$
$$= 5 \times (20 \times 20)$$
$$= 2000 \text{ m}$$

(ii) Time when echo is heard after pebble is dropped

$$T = 20 \text{ s to each the water surface} + \frac{\text{distance}}{\text{speed of sound}}$$
$$= 20 + \frac{2000}{330}$$
$$= 20 + 6.1$$
$$= 26.1s$$



177. A ball is thrown vertically upwards from the top of a tower with an initial velocity of 19.6 ms^{-1}. The ball reaches the ground after 5 s. Calculate :

(i) The height of the tower,

(ii) The velocity of ball on reaching the ground. Take g = 9.8 ms-^{2}.

Ans :

For ball in going from A to B

$$v\ u + gt$$
$$0 = 19.6 - 9.8\,t$$
$$9.8\,t = 19.6$$

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$$t = \frac{19.6}{9.8} = 2\,\text{sec},$$

Time of Ascent = time of descent

T form B to C is also 2 sec.

Time from C to D i.e. top of tower to ground

$$= 5 - 4 = 1\,\text{sec}.$$

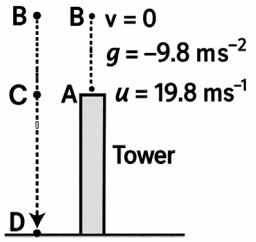
Distance $BC = h_1 = ut + \frac{1}{2}gt^2$

$$= 0 + \frac{1}{2} \times 9.8 \times (2)^2$$

$$= \frac{1}{2} \times 9.8 \times 4$$

$$= 19.6\,\text{m}$$

(i)



Height of tower

$$= BD - BC$$

$$= ut + \frac{1}{2}gt^2 - 19.6$$

$$= 0 + \frac{1}{2} \times 9.8 \times (3)^2 - 19.6$$

$$= 44.1 - 19.6$$

$$= 24.5\,\text{m}$$

(ii) Vel. of ball on reaching the ground

$$v = u + gt$$

$$v = 0 + 9.8 \times 3 = 29.4\,\text{ms}^{-1}$$

CASE BASED QUESTIONS

178. Rahul conducts a physics experiment on a straight athletic track to understand the effect of force on moving bodies. He uses a remote-controlled toy car of mass 2.5 kg that is initially moving with a steady velocity of 4 m/s. Rahul then applies a constant forward force using the car's remote control for a duration of 3.0 seconds. After this time interval, he measures the final velocity of the toy car and records it as 10 m/s. He carefully notes down all the readings in his observation manual to calculate the rate of change of momentum.

(a) Calculate the initial linear momentum and the final linear momentum of the toy car.

(b) Calculate the magnitude of the constant force applied by Rahul on the toy car.

(c) State the law of motion that relates the rate of change of momentum of the toy car to the applied force.

Ans :

(a) Initial Momentum = m × u

Initial Momentum = 2.5 kg × 4 m/s

Initial Momentum = 10 kg m/s

Final Momentum = m × v

Final Momentum = 2.5 kg × 10 m/s

Final Momentum = 25 kg m/s

(b) $\text{Force} = \frac{(\text{Final momentum} - \text{Initial momentum})}{t}$

$$= \frac{25\,\text{kg m/s} - 10\,\text{kg m/s}}{3.0\,\text{s}} = 5\text{N}$$

(c) Newton's second law of motion states that the rate of change of momentum of a body is directly proportional to the applied force and occurs in the force's direction.

179. Meera stands on the terrace of a tall residential building, holding a small metal sphere of mass 0.5 kg in her hand. She drops the metal sphere vertically downwards from rest to observe its motion under the influence of Earth's gravity. She uses a precise digital stopwatch and measures that the sphere takes exactly 4.0 seconds to strike the hard concrete ground below. During her calculations, Meera neglects air resistance and takes the acceleration due to gravity as 9.8 m/s². She records the time of flight to determine the height of the building.

(a) Calculate the total height of the residential building from which Meera dropped the sphere.

(b) Calculate the final velocity with which the metal sphere strikes the concrete ground.

(c) Define the specific term used to describe the downward motion of the metal sphere under gravity alone.

Ans :

(a) Height = ut + (1/2)gt²

Height = (0 m/s × 4.0 s) + (1/2) × 9.8 m/s² × (4.0 s)²

Height = 78.4 m

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(b) Final velocity = u + gt

Final velocity = 0 m/s + (9.8 m/s² × 4.0 s)

Final velocity = 39.2 m/s

(c) Free fall is defined as the downward motion of a freely falling body moving solely under the influence of the Earth's gravitational force without any other external resistance.

180. Sanjay studies the gravitational attraction between celestial bodies for his astronomy project. He gathers data from his textbook regarding two massive spherical asteroids located in deep space. Asteroid Alpha has a mass of 4.0×10^{20} kg, and Asteroid Beta has a mass of 2.0×10^{20} kg. Sanjay notes that the distance separating the centres of these two asteroids is exactly 5.0×10^{6} m. He uses the universal gravitational constant, $G = 6.67 \times 10^{-11}$ N m²/kg², to calculate the attractive pull between them.

(a) Calculate the magnitude of the gravitational force of attraction existing between Asteroid Alpha and Asteroid Beta.

(b) State two specific factors upon which the exact value of the universal gravitational constant G does not depend.

Ans :

(a) Force = $G \times (m_1 \times m_2) / r^2$

Force = 6.67×10^{-11} N m²/kg² × (4.0 × 10^{20} kg × 2.0 × 10^{20} kg) / (5.0 × 10^{6} m)²

Force = 2.1344×10^{17} N

(b) 1. The value of the universal gravitational constant does not depend upon the masses of the two interacting bodies exerting the force.

2. The value of the universal gravitational constant does not depend upon the physical medium present between the two interacting bodies.

181. Kavita packs a specialised scientific instrument in a secure container inside her laboratory on Earth. She measures the mass of the instrument using a calibrated beam balance and records it accurately as 15 kg. The instrument is then loaded onto an uncrewed spacecraft and transported directly to the surface of the Moon. Kavita knows that the acceleration due to gravity on the Earth's surface is 9.8 m/s², while the acceleration due to gravity on the lunar surface is exactly 1.6 m/s². She evaluates how the physical properties of the instrument alter in this new extraterrestrial environment.

(a) Calculate the exact weight of the scientific instrument on the surface of the Earth and on the surface of the Moon.

(b) State the mass of the instrument on the Moon and give one reason why its mass remains constant despite the location change.

Ans :

(a) Weight on Earth = $m \times g_{earth}$

Weight on Earth = 15 kg × 9.8 m/s²

Weight on Earth = 147 N

Weight on Moon = $m \times g_{earth}$

Weight on Moon = 15 kg × 1.6 m/s²

Weight on Moon = 24 N

(b) 1. The mass of the scientific instrument on the lunar surface remains exactly 15 kg.

2. Mass is the constant amount of matter contained in a body, which remains entirely unaffected by the surrounding gravitational field strength.

182. Arjun takes a bus journey to visit his grandparents located in a neighbouring city. He stands in the middle aisle of the crowded bus, gently holding onto the overhead grab rail while the vehicle travels at a high constant speed. Suddenly, a stray animal darts onto the highway, forcing the bus driver to slam hard on the brakes. Arjun observes that his body forcefully pitches forward the moment the bus rapidly decelerates. After the bus comes to a complete halt, he safely alights from the front door to inspect the situation outside.

(a) Name the specific physical property of a body by virtue of which it resists a change in its state of motion.

(b) Give one reason why Arjun's body pitches forward when the driver suddenly applies the brakes.

(c) State what would happen to Arjun's posture if the stationary bus suddenly started moving forward rapidly.

(d) Name the physical quantity that serves as a direct measure of the property named in part (a).

Ans :

(a) The inherent physical property by virtue of which a body strongly resists a change in its state of uniform motion is called the inertia of motion.

(b) When the driver applies brakes, Arjun's feet stop with the bus, but his upper body continues moving forward due to the inertia of motion.

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(c) If the stationary bus suddenly accelerates forward, the lower part of Arjun's body moves, while his upper body falls backward due to the inertia of rest.
(d) The physical quantity that serves as a direct and accurate measure of an object's inertia is the mass of the body.

183. Rohit participates in a local cricket tournament as a fielder positioned near the boundary line. During the final over, the opposing batsman hits a powerful shot, launching a 0.15 kg leather cricket ball high into the air. The ball descends rapidly, reaching a velocity of 20 m/s just before reaching Rohit. He successfully catches the fast-moving ball, bringing it to a complete rest. During the catch, Rohit deliberately pulls his hands backwards, extending the duration of the impact to 0.5 seconds to avoid injuring his palms.
(a) Calculate the magnitude of the change in momentum of the cricket ball during the catch.
(b) Name the combined physical effect of force and time that produces this significant change in momentum.
(c) Give one reason why pulling the hands backwards prevents severe injury to the fielder's palms.
(d) State the standard SI unit of the physical quantity named in part (b).

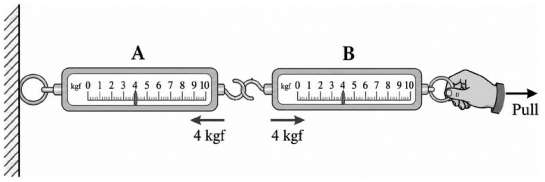
Ans :

(a) Change in momentum

$$= (m \times v) - (m \times u)$$
$$= (0.15\,kg \times 0\,m/s) -$$
$$= (0.15\,kg \times 20\,m/s) = -3.0\,kg\,m/s$$

(b) The physical term representing the combined effect of a force acting for a small duration of time to change momentum is the impulse of force.
(c) Moving the hands backwards significantly increases the time interval of the catch, which directly decreases the rate of change of momentum and the corresponding impact force.
(d) The standard SI unit of the impulse of force is identical to that of momentum, which is measured in kilogram metre per second (kg m/s) or Newton second (N s).

184. Sneha investigates the interaction between forces using laboratory equipment. She connects two identical measuring devices horizontally across a wooden workbench and pulls one end with her hand. The diagram below illustrates the setup where she observes the readings generated on both devices simultaneously.

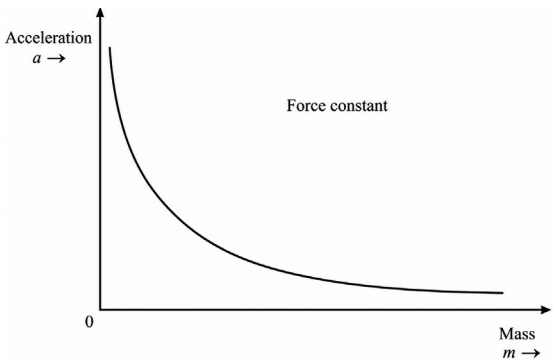


(a) State the magnitude of the force exerted by spring balance B on spring balance A as read directly from the diagram.
(b) State the exact law of physics that is experimentally demonstrated by the identical readings on both spring balances.
(c) Explain how the forces acting on the interconnected hooks relate to each other in terms of magnitude and direction.

Ans :

(a) The magnitude of the force exerted by spring balance B on spring balance A, as shown by the pointer, is exactly 4 kgf.
(b) The identical readings on both spring balances experimentally demonstrate Newton's third law of motion regarding the interaction of bodies.
(c) 1. The pulling force exerted by spring balance A on B is equal in magnitude to the pulling force exerted by B on A.
2. While both interacting forces possess an identical magnitude of 4 kgf, they act simultaneously in completely opposite directions along the same horizontal straight line.

185. Vikram investigates how different masses respond when subjected to a steady external push. He applies exactly the same constant force to multiple wooden blocks of varying masses and measures the resulting acceleration for each block. The graph below displays the data Vikram plotted from his measurements.



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(a) State the specific mathematical relationship between acceleration and mass for a constant force based on the plotted curve.
(b) Calculate the mass of a specific object if the constant applied force is precisely5 N and the acceleration produced is 3.0 m/s².
(c) Name the physical law that mathematically connects the three specific quantities mentioned in the graph's labels.

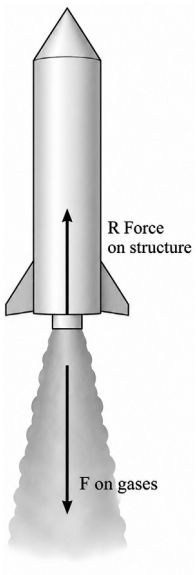
Ans :

(a) The hyperbolic curve on the graph clearly demonstrates that the acceleration produced in a body is inversely proportional to its mass when force is constant.

(b) Mass = Force / Acceleration
= 15 N / 3.0 m/s²
= 5.0 kg

(c) The physical law that defines the quantitative relationship between applied force, mass, and acceleration is Newton's second law of motion.

186. Ananya watches a documentary about space exploration and the launching of large spacecraft. She notes how high-pressure gases are ejected to lift the massive structure off the launch pad. The diagram below illustrates the specific interactions occurring at the tail of the spacecraft.



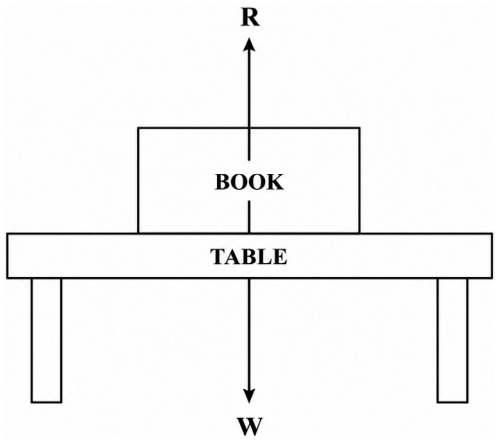
(a) Identify the two physical interacting bodies that actively exert the forces labelled F and R in the provided diagram.
(b) State the exact relationship between the magnitudes and directions of the forces labelled F and R, and name the principle responsible for the upward motion.

Ans :

(a) 1. The first interacting body is the structure or rocket engine which exerts a downward force on the combusted gases to expel them.
2. The second interacting body is the outgoing exhaust gases which exert an upward force on the rocket structure.

(b) 1. The force F acting downwards and the force R acting upwards are perfectly equal in magnitude but act in opposite directions.
2. The upward motion of the structure is a direct consequence of action and reaction forces as stated in Newton's third law of motion.

187. Rohan places a heavy rectangular block on a flat horizontal workbench to study stationary forces. The mass of the block is precisely 2.0 kg, and it rests completely motionless on the surface. The diagram below represents the physical setup and the forces acting vertically on the block.



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(a) Calculate the exact magnitude of the downward force labelled W acting on the block, taking the acceleration due to gravity as 9.8 m/s².
(b) Name the specific upward force labelled R and explain why the block does not move downwards despite the downward force W.

Ans :

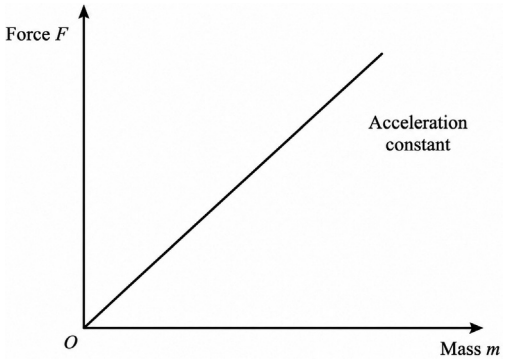
(a) Force W (Weight) = m × g
= 2.0 kg × 9.8 m/s²
= 19.6 N

(b) 1. The upward force labelled R represents the normal reaction force exerted by the

horizontal table on the stationary block.

2. The block does not move downwards because the table exerts an equal and opposite normal reaction force that completely balances the downward weight.

188. Sunita performs a physics experiment to determine the required effort to accelerate various objects equally. She ensures that every object achieves an exact acceleration of 5.0 m/s² and records the necessary force for each object's mass. The graph below illustrates the direct relationship Sunita found between the two quantities.



(a) State the relationship between the quantities plotted on the two axes based on the straight diagonal line shown.

(b) Calculate the precise force required based on the graph's conditions if an object has a mass of 4.5 kg.

(c) Name the physical cause that successfully changes the state of rest or uniform motion of a body.

(d) State the CGS unit of the physical quantity plotted on the vertical axis.

Ans :

(a) The straight line originating from the intersection point demonstrates that the force applied is directly proportional to the mass when acceleration remains constant.

(b) Force = m × a

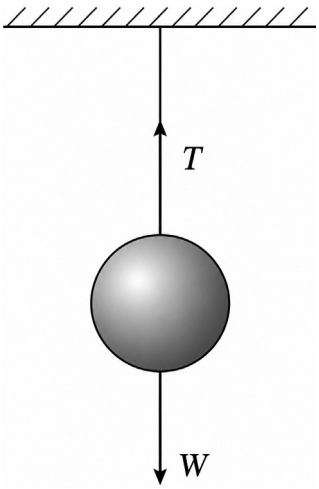
= 4.5 kg × 5.0 m/s²

= 22.5 N

(c) The physical external influence or cause that can actively change the state of rest or state of motion of a body is called force.

(d) The standard CGS unit of the physical quantity force plotted on the vertical axis of the given graph is the dyne.

189. Manish hangs a small metallic sphere from the ceiling of the laboratory using an inextensible cotton thread. The mass of the metallic sphere is carefully measured to be exactly 0.4 kg. The diagram below illustrates the forces developed in this specific suspended arrangement while the sphere remains entirely motionless.



(a) Name the specific contact force labelled T that is developed in the vertical string.

(b) Calculate the exact magnitude of the downward force W acting on the sphere, taking g = 9.8 m/s².

(c) State the exact magnitude of the upward force T required to keep the metallic sphere in its motionless equilibrium position.

(d) Name the specific type of fundamental non-contact force that causes the downward pull labelled W.

Ans :

(a) The specific upward contact force labelled T that is developed inside the stretched supporting string is called the force of tension.

(b) Weight (W) = m × g

= 0.4 kg × 9.8 m/s²

= 3.92 N

(c) To maintain the sphere in a perfect state of equilibrium, the magnitude of the upward tension force T must be exactly 3.92 N.

(d) The fundamental non-contact force that is responsible for pulling the metallic sphere downwards towards the Earth is the gravitational force.

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CHAPTER 4

Pressure in Fluids and Atmospheric Pressure

SUMMARY

1. THRUST

Thrust is the force acting perpendicularly on the surface of an object. It is a vector quantity, which means it has both magnitude and direction. The SI unit of thrust is newton (N).

2. PRESSURE

Pressure is the force or thrust acting perpendicularly on a unit area of the object.

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}} = \frac{F}{A}$$

The same force acting on a smaller area exerts a larger pressure and on a larger area exerts a smaller pressure. The SI unit of pressure is N/m^2. This unit is named as pascal (Pa). One pascal is the pressure exerted on a surface of area 1 m^2 by a force of 1 N acting normally on it.

3. PRESSURE IN FLUIDS

A substance which flows is called a fluid. Fluids exert pressure on the base and walls of the container in which they are enclosed. Pressure exerted in any confined mass of fluid is transmitted uniformly in all directions.

3.1 Pressure Exerted by a Liquid Column :

The pressure on a surface at a depth 'h' is

$$P = \frac{\text{Thrust of surface}}{\text{Area of surface}} = \frac{Ahpg}{A} = hpg$$

The total pressure inside a liquid column at a depth is the sum of the atmospheric pressure on the liquid surface and the pressure due to the liquid column.

$$\text{Total pressure} = P_0 + hpg$$

3.2 Laws of Liquid Pressure

The Laws of liquid pressure are as follows :

1. Pressure is the same in all directions about a point in the liquid.
2. In a stationary liquid, the pressure is the same at all points on a horizontal plane.
3. Pressure at a point inside the liquid increases with depth from the free surface.
4. Pressure at the same depth is different in different liquids. It increases with increase in density.
5. A liquid seeks its own level.

Some Consequences of Liquid Pressure

6. The wall of a dam is made thicker at the bottom.
7. To supply water to a town (or a colony), the water supply tank is placed at a sufficient height.
8. Deep sea divers need to wear a special protective suit. In the deep sea, the total pressure exerted on the diver's body is much more than his blood pressure.

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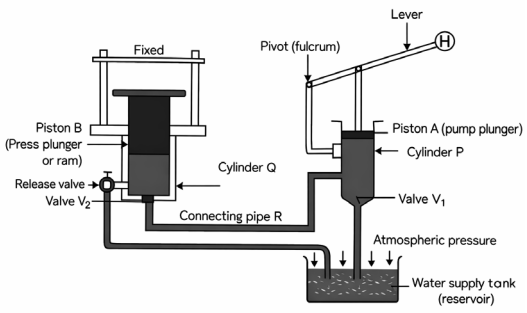
4. PASCAL'S LAW

The pressure exerted anywhere in a confined liquid is transmitted equally and undiminished in all directions throughout the liquid.

Application of Pascal's law

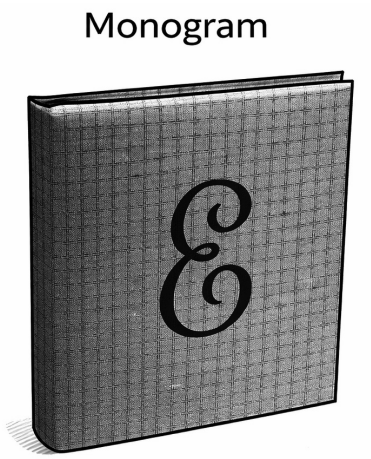
The hydraulic press, hydraulic jack and hydraulic brakes work on Pascal's law of transmission of pressure. Examples of Hydraulic Machines

Hydraulic Press (Bramah Press)



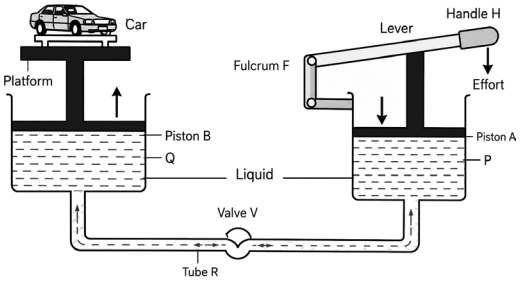
Uses

1. For engraving monograms on books.
2. For extracting juice from sugarcane.
3. For squeezing oil from linseed and cotton seeds.
4. For pressing cotton bales and goods, quilts, books etc.



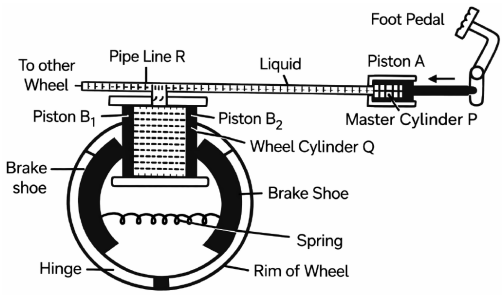
4.1 Hydraulic jack

A hydraulic jack is used to lift heavy vehicles at service stations for repair works.



HYDRAULIC JACK

4.2 HYDRAULIC BREAK



HYDRAULIC BRAKE

5. ATMOSPHERIC PRESSURE

The envelope of air surrounding the Earth is called the atmosphere. The thrust exerted per unit area of the Earth's surface due to a column of air is called the atmospheric pressure on the Earth's surface.

Its value is about 1 kgf/cm^2

$= 10^5$ N m^{-2} $= 10^5$ Pa .

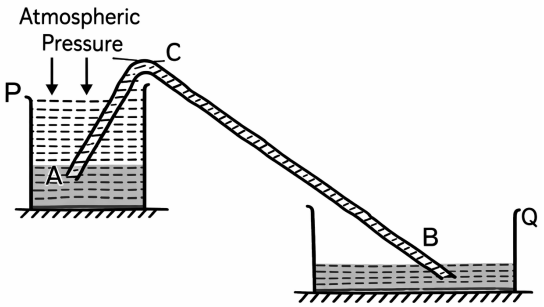
We do not feel this large amount of thrust as our blood pressure balances this thrust.

1 atm = 0.76 m of Hg

$= 75$ cm of Hg $= 1.013 \times 10^5$ Pa

Consequences of Atmospheric Pressure

1. We can suck a drink with a straw
2. We can fill a syringe with the liquid
3. We can fill ink into a fountain Pen
4. Rubber suckers work due to atmospheric pressure
5. Action of a siphon system is based on atmospheric



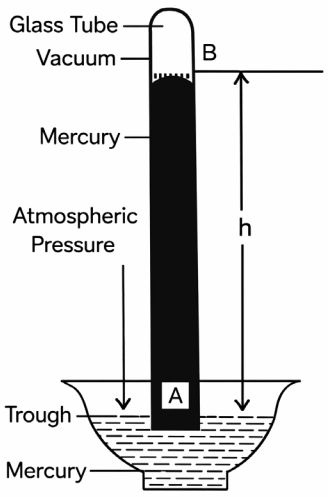
HYDRAULIC BRAKE

5.1 Measurement of Atmospheric Pressure

Atmospheric pressure is measured using a barometer.

Simple barometer

1. Torricelli first designed a simple barometer using mercury as the barometric liquid.



Simple barometer

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Advantages of using mercury as a barometric liquid

2. The density of mercury is greater than that of all other liquids, so only 0.76 m height of the mercury column is needed to balance the normal atmospheric pressure.
3. The vapour pressure of mercury is negligible, so it does not affect the barometric height.
4. The mercury neither wets nor sticks to the glass tube. Therefore, it gives the correct reading.
5. The surface of mercury is shining and opaque. Therefore, it is easily seen while taking the observation.
6. It can easily be obtained in the pure state.

Disadvantages of using water as a barometric liquid

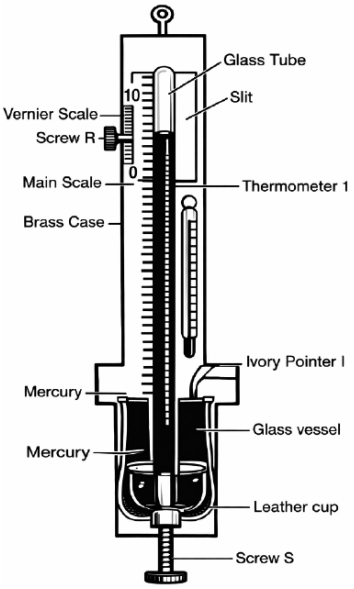
7. The density of water is low, so nearly 10.4 m height of the water column is needed to balance the normal atmospheric pressure. It will be very inconvenient to use a tube of height 10.4 m for a barometer.
8. The vapour pressure of water is high, so the vapours in the vacuum space will make the reading inaccurate.
9. Water sticks to the glass tube and wets it, so the reading becomes inaccurate.
10. Because water is transparent, its surface is not easily seen while taking the observation.

Defects of a simple barometer

11. There is no protection for the glass tube.
12. The surface of mercury in the trough is open; therefore, there are chances that the impurities may fall in and get mixed with the mercury of the trough.
13. It is inconvenient to move the barometer from one place to another.
14. A scale cannot be fixed with the tube (or it cannot be marked on the tube) to measure the atmospheric pressure.

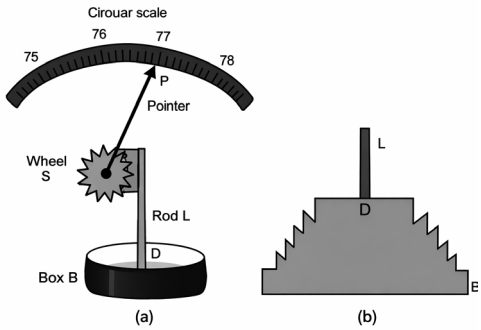
Fortin's barometer

It is a modified form of a simple barometer. It is used in the laboratory to measure the atmospheric pressure. It also uses mercury as barometric liquid.



Aneroid barometer

This barometer does not have a liquid. It is light and portable. Hence, it can easily be carried from one place to another. It is calibrated in such a way that it reads the atmospheric pressure directly.



Uses of a barometer

15. To measure the atmospheric pressure at a place
16. For weather forecast
17. As an altimeter

Variation of atmospheric pressure with altitude

18. The pressure of air decreases with increase in altitude.
19. The decrease in atmospheric pressure is due to
    (a) Decrease in height of the air column which causes a linear decrease in atmospheric pressure.
    (b) Decrease in density of air which makes the decrease in atmospheric pressure less rapid with increase in altitude.
20. The following graph shows the variation of atmospheric pressure with height above sea level.

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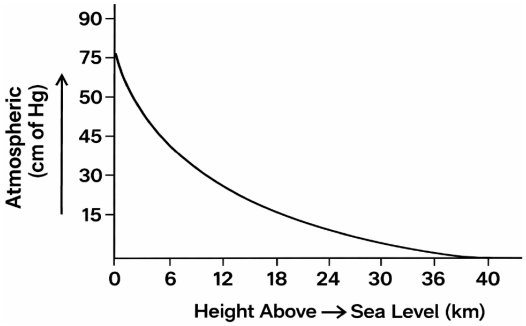

Consequences of travelling to high altitudes

21. The air pressure reduces and hence breathing problems occur. Also, the nose may bleed.
22. A fountain pen will start leaking due to the pressure difference at a high altitude compared to the air pressure on the surface.

Weather Forecast by a Barometer

23. A weather forecast is done as follows:
24. If the barometric height at a place falls, then it means that the pressure at that place has fallen, indicating the coming of a storm or cyclone.
25. If the barometric height gradually falls, then it indicates that the moisture is increasing, i.e., there is a possibility of rain.
26. A gradual increase in the barometric height means that the moisture in the air is decreasing. This indicates dry weather.

PRESSURE IN FLUIDS AND ATMOSPHERIC PRESSURE

27. A sudden rise in the barometric height means a flow of air from that place to surrounding low pressure areas. This indicates extremely dry weather.
28. If there is no abrupt change in the barometric height, then it indicates that the atmospheric pressure is normal, i.e., the weather is fair.

Altimeter

29. An altimeter is a device used in an aircraft to measure its altitude. Because the atmospheric pressure decreases with the increase in height above the sea level, a barometer measuring the atmospheric pressure can be used to determine the altitude of a place above the sea level.
30. An aneroid barometer which has the scale calibrated in terms of height of ascent can be used as an altimeter.
31. The scale of an altimeter is graduated with height increasing towards the left because the atmospheric pressure decreases with increase of height above the sea level.

OBJECTIVE QUESTIONS

1. Which of the following accurately describes thrust and its corresponding gravitational unit in the MKS system?
(A) Scalar quantity, measured in dyne
(B) Vector quantity, measured in newton
(C) Scalar quantity, measured in pascal
(D) Vector quantity, measured in kgf

Ans : (D)

Thrust is defined as the force acting normally on a surface. It is a vector quantity because it acts in one particular direction. The SI unit of thrust is newton, while its gravitational unit in the MKS system is the kilogram-force.

2. Three vessels—a narrow cylinder (X), a wide cylinder (Y), and a conical flask (Z)—are filled with the same liquid to the same vertical height 'h'. The pressure is measured at the bottom centre of each vessel.

Vessel	Shape	Liquid	Vertical Height of Liquid	Base Pressure
X	Narrow Cylinder	Water	h	P_x
Y	Wide Cylinder	Water	h	P_y
Z	Conical Flask	Water	h	P_z

How do the pressures P_x, P_y, and P_z compare?
(A) $P_x > P_y > P_z$
(B) $P_z > P_y > P_x$
(C) $P_x = P_y = P_z$
(D) $P_y > P_x = P_z$

Ans : (C)

According to the laws of liquid pressure, the pressure at a certain depth within a liquid depends only on the vertical height (h), density of the liquid (ρ), and g. It is independent of the shape of the container or the volume of the liquid. Since h and ρ are the same for all three vessels, the pressure at the base is equal: $P_x = P_y = P_z$.

3. How does a sharp needle functionally differ from a blunt spoon when pressed against the skin with the exact same amount of applied force?
(A) It decreases the thrust exerted on the skin.
(B) It increases the thrust exerted on the skin.
(C) It decreases the area, thereby increasing the pressure.

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(D) It increases the area, thereby decreasing the pressure.

Ans : (C)

The effect of thrust depends on the area of the surface on which it acts. It is less on a large area and more on a small area. This physical quantity is known as pressure, which is a scalar quantity.

4. Why are wide wooden sleepers deliberately placed exactly below heavy railway iron tracks?
(A) To strictly increase the total thrust acting on the ground.
(B) To strictly decrease the total thrust acting on the ground.
(C) To increase the contact area, thereby reducing the pressure.
(D) To decrease the contact area, thereby increasing the pressure.

Ans : (C)

For a given thrust, the pressure on a surface is reduced by increasing the surface area. Wide wooden sleepers are placed below railway tracks so that the immense pressure exerted by the heavy iron rails on the ground becomes significantly less.

5. Consider the following statements regarding the behaviour of pressure exerted by fluids and completely solid objects:
I. A solid securely exerts pressure strictly on its bottom horizontal surface.
II. A contained fluid naturally exerts pressure only on the vertical walls.
III. A contained fluid fundamentally exerts pressure at all internal points.
IV. A fluid forcefully exerts pressure uniformly in all possible directions.
Which of the given combinations of statements is entirely correct?
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

Ans : (B)

A fluid contained in a vessel exerts pressure at all points and in all directions. A solid exerts pressure only on its bottom surface, but a fluid exerts pressure on the bottom as well as on the walls of the container.

6. What exactly safely completely completely fills the completely entirely empty physical space intentionally left perfectly above the high mercury column directly inside a simple barometer tube?
(A) Only highly compressed normal atmospheric air
(B) A perfectly pure mixture of local atmospheric gases
(C) Only tiny trace amounts of absolute mercury vapours
(D) Completely absolutely completely ordinary clean tap water

Ans : (C)

When an inverted glass tube is placed in a mercury trough, the mercury level falls and stabilizes at seventy-six centimetres. The empty region left above the mercury column strictly contains mercury vapours and is formally known as the Torricellian vacuum.

7. An enclosed, fluid-filled container has pressure sensors at points X, Y, and Z, all at the same horizontal level. Initially, the fluid is at rest. An external force increases the pressure at point X by 50 kPa.

Sensor Point	Initial Pressure (kPa)	Final Pressure (kPa)
X	100	150
Y	100	Py
Z	100	P_z

According to Pascal's Law, what will be the final pressures P_y and P_y?
(A) $P_y = 100$ kPa, $P_2 = 100$ kPa
(B) $P_y = 125$ kPa, $P_2 = 125$ kPa
(C) $P_y = 150$ kPa, $P_2 = 150$ kPa
(D) $P_y = 200$ kPa, $P_2 = 200$ kPa

Ans : (C)

ascal's Law states that a pressure change applied to an enclosed, incompressible fluid is transmitted undiminished to every portion of the fluid and the walls of the containing vessel. Since the pressure at point X was increased by 50 kPa, this same increase is transmitted to points Y and Z, making their final pressures 100 + 50 = 150 kPa.

8. **Assertion (A) :** It is practically much easier to effortlessly cut an apple with a perfectly sharp knife than a completely blunt one.
Reason (R) : A smaller contact area of the extremely sharp edge forcefully exerts a significantly greater pressure for the exact same applied thrust.
(A) Both A and R are true and R is the correct explanation of A

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(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The cutting tools always have either sharp or pointed edges so that even a small thrust may cause a great pressure at the edges. Thus, a sharp knife decreases the area of contact, increasing the pressure and making cutting easier.

9. Which mathematical relation correctly represents the total hydrostatic pressure P exerted exclusively by a stationary liquid column?
(A) $P = \frac{h}{p}g$
(B) $P = hpg$
(C) $P = p\frac{g}{h}$
(D) $P = h + pg$

Ans : (B)

The pressure exerted by a liquid of density p at a depth h is directly proportional to both the depth and the density of the liquid. It is mathematically given by the product of depth, liquid density, and acceleration due to gravity.

10. Which of the following distinct physical parameters does NOT fundamentally affect the pressure measured at a specific point inside a stationary liquid?
(A) Vertical depth of the measuring point below the free surface
(B) Overall geometric shape and total size of the containing vessel
(C) Intrinsic material density of the specific liquid being utilized
(D) Standard local acceleration due to gravity at that specific place

Ans : (B)

The pressure at a point in a liquid does not depend on the shape and size of the containing vessel. It only depends on the depth of the point, the density of the liquid, and the acceleration due to gravity.

11. Consider the fundamentally established laws governing hydrostatic pressure mathematically inside any confined stationary liquid:
I. Inside a stationary liquid, pressure at a point steadily increases directly with its vertical depth.
II. In a completely stationary liquid, pressure invariably remains perfectly uniform on a horizontal plane.
III. Pressure measured at the exact same depth firmly remains absolutely identical across all different liquids.
IV. Any given stationary liquid consistently seeks and accurately maintains its own completely flat horizontal level.
Which of the given combinations correctly reflects the laws of liquid pressure?
(A) I, II, and III
(B) II, III, and IV
(C) I, II, and IV
(D) I, III, and IV

Ans : (C)

According to the fundamental laws of liquid pressure, pressure is the same in all directions about a point inside the liquid. Furthermore, a stationary liquid finds its own level, and pressure varies due to the distinct densities of different liquids.

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12. A submarine's depth gauge measures its depth below the sea surface. The table shows the gauge pressure (liquid pressure) at different depths. Given that the atmospheric pressure at the sea surface is 100,000 Pa.

Observation	**Depth (m)**	**Gauge Pressure (h ρ g) (Pa)**
1	10	102,000
2	20	204,000
3	30	306,000

What is the absolute (total) pressure experienced by the submarine at a depth of 20 metres?
(A) 104,000 Pa
(B) 204,000 Pa
(C) 304,000 Pa
(D) 408,000 Pa

Ans : (C)

The absolute pressure at a certain depth is the sum of the atmospheric pressure and the gauge pressure ($P_{total} = P_{atm} + P_{gauge}$). At a depth of 20 metres, the gauge pressure is 204,000 Pa. Adding the atmospheric pressure gives: Absolute Pressure = 100,000 Pa + 204,000 Pa = 304,000 Pa.

13. Why is the primary structural foundation base of a massive water dam strategically constructed to be significantly broader than its top?
(A) To aggressively decrease the total volume of

water tightly held inside the deep reservoir.
(B) To confidently withstand the incredibly immense liquid pressure physically acting at the maximum vertical depth.
(C) To forcefully push the water rapidly upwards against the downward pull of standard gravity.
(D) To effectively lower the overall material density of the extremely large surrounding water body.

Ans : (B)

The wall of a dam is constructed to be much thicker towards the bottom compared to the top. This structural design is necessary because the pressure exerted by water increases considerably with depth, becoming maximum at the dam's lowest vertical point.

14. **Assertion (A) :** An underwater gas bubble naturally grows significantly larger in physical size as it steadily rises from the lake's bottom.
Reason (R) : The total hydrostatic liquid pressure continuously decreases directly as the vertical depth practically reduces towards the open surface.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

When a gas bubble rises towards the surface, the liquid pressure decreases due to a reduction in depth. Since the total pressure exerted on the bubble drops, the volume of the trapped gas expands, causing the bubble to grow larger.

15. Which fundamental mathematical equation correctly represents the underlying working principle functionally operating behind a standard mechanical hydraulic machine?
(A) $F_1 A_1 = F_2 A_2$
(B) $F_1 / A_1 = F_2 / A_2$
(C) $F_1 + A_1 = F_2 + A_2$
(D) $F_1 - A_2 = F_2 - A_1$

Ans : (B)

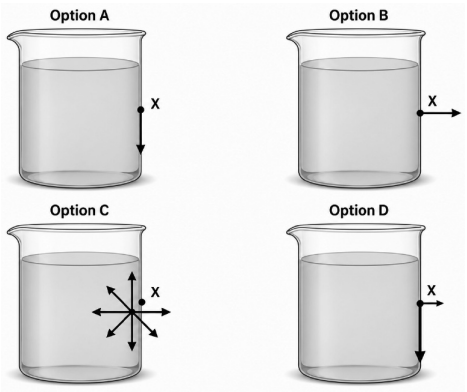
A hydraulic machine operates on the principle that a small force applied on a smaller piston is transmitted to produce a larger force on a bigger piston. It effectively acts as a force multiplier by utilizing varying areas of cross-section.

16. Which fundamental scientific principle strictly governs the equal and completely undiminished transmission of applied pressure throughout an enclosed fluid?
(A) Torricelli's structural principle
(B) Archimedes' fundamental law
(C) Newton's absolute fluid theory
(D) Pascal's pressure transmission law

Ans : (D)

Pascal's law states that a change in pressure at any point in an enclosed fluid at rest is transmitted equally and undiminished in all directions throughout the fluid. This foundational principle forms the functioning basis for various heavy hydraulic machines.

17. A vessel is filled with a liquid. Which of the diagrams correctly represents the direction of pressure exerted by the liquid on the walls of the vessel at a point X?



(A) A single arrow pointing downwards from X.
(B) A single arrow pointing horizontally outwards from X.
(C) Arrows of equal length pointing in all directions from X.
(D) A larger arrow downwards and a smaller arrow outwards from X.

Ans : (C)

A fundamental property of fluids is that they exert pressure equally in all directions at any given point within the fluid. This is independent of the shape of the container. Therefore, at any point X, the pressure acts upwards, downwards, and sideways with equal magnitude, pressing on any surface it contacts or on adjacent fluid particles.

18. Match the highly specific practical applications related strictly to liquid pressure with their corresponding fundamental scientific explanations

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correctly.
List-I (Application)
P. High-altitude municipal water supply tank
Q. Specialized heavy-duty deep-sea diver's suit
R. Exceptionally broad base of a river dam
S. Expanding underwater rising gas bubble
List-II (Explanation)
I. Purposefully securely withstands incredibly massive surrounding bottom-level water thrust.
II. Successfully ensures a remarkably high continuous liquid pressure flowing at lower taps.
III. Protects the human body from violently crushing hydrostatic deep-water pressure.
IV. Internal volume systematically increases specifically due to rapidly dropping external depth-pressure.
(A) P-II, Q-III, R-I, S-IV
(B) P-III, Q-II, R-IV, S-I
(C) P-I, Q-IV, R-II, S-III
(D) P-II, Q-I, R-III, S-IV

Ans : (A)

Sea divers wear special protective suits made from reinforced plastic or cast aluminium to withstand immense deep-water pressure. Water supply tanks are elevated to maintain high pressure. Gas bubbles expand as depth decreases, and dam bases are thickened for stability.

19. Which specific combination strongly identifies the completely accurate industrial applications practically executed by utilizing a modern heavy hydraulic press?
(A) Actively pumping local ground water and efficiently printing thick digital paper books.
(B) Safely controlling speeding automobiles and properly forecasting harsh local weather.
(C) Tightly pressing raw cotton bales and securely compacting powdered metallic parts.
(D) Directly recording absolute atmospheric pressure and properly calculating aircraft flight altitude.

Ans : (C)

A hydraulic press is a device that utilizes a hydraulic cylinder to generate a massive compressive force. It is extensively used in industries for pressing cotton bales, compacting powdered metal parts, squeezing goods like quilts, and forming durable glass products.

20. **Assertion (A) :** A well-designed mechanical hydraulic machine acts effectively and remarkably as an incredibly highly efficient physical force multiplier.
Reason (R) : The total mechanical work done directly by the smaller effort is significantly greater than the total work done on the heavier load.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

While a hydraulic machine successfully acts as a force multiplier, the work done by the effort is exactly equal to the work done on the load in an ideal situation. Energy is always conserved, so no extra work is ever created.

21. An experiment is conducted to see how different conditions affect the reading of a simple mercury barometer that initially reads 76 cm at sea level.

Trial	Action Taken
P	The barometer tube is tilted at a 30° angle.
Q	The barometer is taken to the top of a high mountain.
R	Some air is introduced into the Torricellian vacuum.
S	The barometer is used in a room with higher temperature.

Which of the following actions would cause the vertical height of the mercury column to decrease?
(A) P only
(B) P and Q
(C) Q, R, and S
(D) P, Q, R, and S

Ans : (C)

Moving to a higher altitude (Q) decreases atmospheric pressure. Introducing air (R) creates a pressure that pushes the column down (faulty barometer). Higher temperature (S) makes the surrounding air less dense, lowering atmospheric pressure. Tilting the tube (P) does not change the vertical height, only the length of mercury along the tube increases.

22. What exactly is the specific internal chemical composition typically found deeply inside the special controlling fluid used completely within vehicle hydraulic brakes?
(A) Highly purified dense liquid mercury

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exclusively.
(B) Standard clean municipal drinking water mostly.
(C) Specially formulated liquid containing ethylene glycol typically.
(D) Highly pressurized compressed atmospheric oxygen entirely.

Ans : (C)

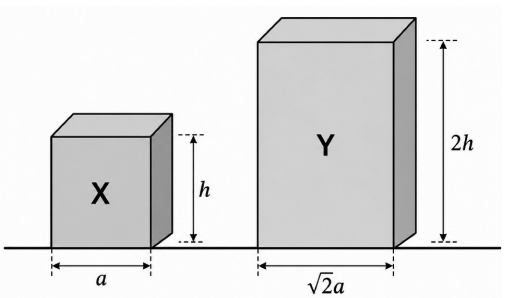
The hydraulic brake is a specialized arrangement of braking mechanisms that strictly relies on hydraulic fluid to transfer pressure. This fluid typically contains ethylene glycol, which efficiently transfers the pressure from the controlling pedal mechanism directly to the braking mechanism.

23. Why precisely does liquid physically forcefully rush upwards directly into the narrow glass barrel of a medical syringe immediately when the internal plunger is deliberately pulled up?
(A) The upward pulling action permanently destroys the entire local atmospheric pressure.
(B) The internal atmospheric pressure actively forcefully pulls the underlying liquid upward.
(C) The internal pressure strongly increases, actively drawing the external liquid smoothly inside.
(D) The internal pressure sharply decreases, powerfully allowing external atmospheric pressure to push liquid inside.

Ans : (D)

When the plunger of a syringe is pulled up, it effectively creates a low-pressure region inside the barrel. The relatively higher external atmospheric pressure then pushes the liquid steadily upward into the syringe, allowing it to be filled quite effortlessly.

24. Two solid blocks, X and Y, made of the same material, are placed on a horizontal table. Block Y has twice the base area and twice the height of block X. If the pressure exerted by block X is P, what is the pressure exerted by block Y?



(A) P/2
(B) P
(C) 2P
(D) 4P

Ans : (C)

Explanation: Pressure is given by $P = F/A$, where F is the weight (mg) and A is the base area. Let the density be ρ.

$$\text{Pressure of X} = (\text{Volume\_X} \times \rho \times g) / \text{Area\_X}$$
$$= (a^2h \times \rho \times g) / a^2 = h\rho g.$$
$$\text{Pressure of Y} = (\text{Volume\_Y} \times \rho \times g) / \text{Area\_Y}$$
$$= ((2a^2) \times 2h \times \rho \times g) / (2a^2)$$
$$= 2h\rho g.$$

Thus, the pressure exerted by block Y is twice that of block X.

25. Carefully review the following distinct mathematical values regarding the standard measurement of absolute normal atmospheric pressure physically resting exactly on the earth's surface:
I. Approximately 1 kgf per perfectly square centimetre.
II. Exactly equivalent to 1.013 multiplied by ten to the power of five pascal.
III. Absolutely equal to precisely 0.76 metres of a standard mercury column.
IV. Roughly estimated to be exactly 10 newtons acting strictly per perfectly square metre.
Which strictly given numerical combination accurately provides the precisely correct values?
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (A)

The atmospheric pressure on the earth's surface is approximately 1 kgf per square centimetre. This is exactly equivalent to exactly 1.013 times ten to the power of five pascal, or a barometric height of exactly 0.76 metres of a mercury column.

26. What fundamentally scientifically occurs deeply inside a fully sealed heated tin can filled initially with incredibly hot steam absolutely the moment cold water is suddenly poured over it?
(A) The internal steam pressure rapidly increases violently.
(B) The internal steam aggressively directly expands completely outwards.
(C) The internal steam sharply condenses, remarkably decreasing the internal pressure instantly.

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(D) The extremely cold water physically quickly enters directly through the sealed top.

Ans : (C)

When a heated, steam-filled tin can is sealed and cooled with water, the internal steam rapidly condenses into water. This dramatically drops the internal pressure, allowing the much stronger external atmospheric pressure to crush and collapse the tin can inward.

27. Correctly match the specific practical devices operating directly on the powerful fundamental physical principle of existing standard atmospheric pressure with their highly specific functional mechanisms.

List-I (Device)

P. Traditional bent rubber siphon system
Q. Small domestic flexible rubber sucker
R. Heavy-duty electrical vacuum cleaner
S. Simple thin plastic drinking straw

List-II (Mechanism)

I. Actively lowers internal air pressure to heavily suck thick dust inside perfectly.
II. Relies strictly on human lungs to lower internal air pressure for comfortable fluid rising.
III. Uses distinctly different liquid levels to smoothly transfer fluids completely downhill.
IV. Trapped internal air is physically pushed out strictly creating a very strong secure vacuum seal.

(A) P-IV, Q-III, R-I, S-II
(B) P-III, Q-IV, R-I, S-II
(C) P-III, Q-I, R-IV, S-II
(D) P-I, Q-IV, R-III, S-II

Ans : (B)

A siphon seamlessly transfers liquid to a lower level. A vacuum cleaner actively lowers internal air pressure to suck in dust. A drinking straw utilizes reduced internal pressure. Rubber suckers firmly stick to smooth surfaces due to external atmospheric pressure.

28. The table shows the specifications of a hydraulic brake system. A force is applied by the driver on the foot pedal, which is transmitted to the master cylinder piston.

Component	Area	Force
Master Piston	$A_1 = 2$ cm^2	F_1 (Driver's Effort)
Wheel Piston	$A_2 = 24$ cm^2	$F_2 = 600$ N

What is the minimum force (F_1) the driver must apply to the master piston to generate the required braking force of 600 N at the wheel piston?

(A) 25 N
(B) 50 N
(C) 100 N
(D) 600 N

Ans : (B)

According to the principle of hydraulic machines, the pressure is transmitted equally: $F_1/A_1 = F_2/A_2$. To find the required input force F_1, we rearrange the formula to $F_1 = F_2 \times (A_1/A_2)$. Substituting the given values: $F_1 = 600$ N $\times$ (2 cm^2 / 24 cm^2) = 600 N $\times$ (1/12) = 50 N.

29. **Assertion (A) :** Exactly two physically distinct holes must importantly be made in a completely filled sealed tin can to successfully properly pour out oil.

Reason (R) : Fresh external air firmly enters exclusively through the second hole to constantly forcefully exert adequate atmospheric pressure directly upon the internal oil.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

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Ans : (A)

Extracting oil from a sealed can requires making two distinct holes. One hole allows the liquid to pour out, while the second hole permits external air to enter and apply necessary atmospheric pressure, facilitating a smooth and continuous oil flow.

30. Who historically accurately designed the world's very first fully functional simple experimental scientific barometer strictly utilizing highly purified liquid mercury?

(A) The prominent scientist Blaise Pascal
(B) The famous physicist Isaac Newton
(C) The brilliant scientist Evangelista Torricelli
(D) The highly regarded researcher Lucien Vidi

Ans : (C)

In the year sixteen forty-three, the brilliant scientist Evangelista Torricelli successfully designed the first simple barometer. He creatively utilized mercury in a one-metre long glass tube to accurately demonstrate and measure the prevailing atmospheric pressure acting upon the earth's surface.

31. Evaluate the completely following scientific reasons strictly strongly justifying the widespread absolute use of completely pure liquid mercury strictly as a standard barometric fluid:

I. Its unusually highly exceptional liquid density efficiently requires a completely realistically manageable short glass tube.

II. Its surprisingly extremely low internal vapour pressure ensures practically completely a very clean upper vacuum.

III. It stubbornly practically rarely ever properly physically sticks directly onto the internal clear glass tube walls.

IV. It fundamentally strictly completely completely transparently effortlessly completely visually strictly heavily blends exactly perfectly with the transparent glass completely.

Which distinct combination accurately correctly properly highlights entirely strictly perfectly its physical actual scientific advantages?

(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

Ans : (A)

Mercury is exclusively preferred as a reliable barometric liquid because it possesses an exceptionally high density and a very low vapour pressure. Furthermore, it firmly avoids sticking to glass surfaces and has an opaque, shining appearance for incredibly clear observations.

32. Which fundamental specific physical characteristic strictly crucially ultimately importantly prevents extremely ordinary clean tap water from effectively constantly reliably functioning completely as a standard standard barometric liquid?

(A) Its surprisingly extremely phenomenally massively unmanageable immense exceptionally exceptionally density precisely.
(B) Its highly significantly deeply excessively vividly bright strictly clearly visible dark internal coloration accurately.
(C) Its unusually extremely incredibly drastically significantly terribly low perfectly exactly standard physical density carefully.
(D) Its remarkably completely surprisingly utterly practically heavily exactly extremely strictly very terribly perfectly dry chemical nature effectively.

Ans : (C)

Water is strongly discouraged for making barometers because its extremely low density would impractically require a massive ten-point-four metre tall glass tube. Additionally, it frustratingly sticks to glass walls, readily evaporates, and its transparent nature makes accurate visual readings quite difficult.

ONE MARK QUESTIONS

33. State whether thrust is a scalar or vector ?

Ans :
Thrust is a vector quantity.

34. State whether pressure is a scalar or vector ?

Ans :
Pressure is a scalar quantity.

35. Write the numerical value of the atmospheric pressure on the surface of earth in pascal.

Ans :
It is about 105 Pa.

36. What is a fluid ?

Ans :
A substance which can flow is called a fluid. For example, all liquids and gases are fluids.

37. Define the term thrust. State its S.I. unit.

Ans :
Thrust : "Force acting normally on the surface is called Thrust." S.I. unit is newton [N].

38. (a) What physical quantity is measured in bar ?
(b) How is the unit bar related to the S.I. unit pascal?

Ans :
(a) Pressure is measured in bar.
(b) Pressure of 1 bar $=10^5$ Nm^{-2} or 10^5 pascal

39. Define one pascal (Pa), the S.I. unit of pressure.

Ans :
Pascal (Pa) : "Is the pressure exerted on a surface of area 1m2 by thrust of 1N".
S.I. unit of pressure is Nm^{-2}

40. How does the liquid pressure on a diver change if:
(i) the diver moves to the greater depth, and
(ii) the diver moves horizontally ?

Ans :
(i) Liquid pressure increases..
(ii) Liquid pressure remians the same.

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41. A dam has broader walls at the bottom than at the top. Explain.

Ans :
To withstand the greater pressure of water which increases with increase in depth.

42. What do you understand by atmospheric pressure?

Ans :
Atmospheric pressure : "The thrust due to atmospheric air on unit area" is called atmospheric pressure.

43. Why is the tip of an all pin made sharp ?

Ans :
A sharp tip is provided at the end of a pin so that pressure$\left(\frac{\text{force}}{\text{area}}\right)$ exerted by it is maximum when it is pressed by a given force.

44. State Pascal's law of transmission of pressure.

Ans :
Pascal's Law : "The pressure applied on the surface of a confined liquid is transmitted equally and undiminished in all directions throughout the liquid."

45. Name two applications of Pascal's law.

Ans :
Two applications are :
(a) Hydraulic brakes
(b) Hydraulic jack.

46. State two uses of a barometer.

Ans :
(i) It is used to measure atmospheric pressure at a place.
(ii) It is used for weather forecast.

47. What do you mean by the term fluid pressure?

Ans :
Fluid Pressure : Pressure exerted by fluid (Substance like liquids and gases which can flow) contained in a vessel in all directions and at all points is called fluid pressure.

48. Name the physical quantity which is expressed in the unit 'atm'. State its value in pascal.

Ans :
The atmospheric pressure is 1 atm which means that atmospheric pressure is 0.76 m of Hg. Its value in pascal is $= 1.013 \times 10^5$ pascal.

49. What is the purpose of a barometer ?

Ans :
Purpose of barometer is to measure atmospheric pressure at a place.

50. Why do sea divers need special protective suite?

Ans :
In a deep sea, the total pressure exerted on the diver's body becomes much more than his blood pressure. To withstand it, the sea divers need special protective suit.

51. We do not feel uneasy even under enormous pressure of atmosphere above as well as around us. Give a reason.

Ans :
Blood in our body exerts Blood pressure which is slightly more than atmospheric pressure and we do not feel uneasy.

52. What is meant by the statement 'the atmospheric pressure at a place is 76 cm of Hg" ? State its value in Pa.

Ans :
The statement means that 76 cm column of mercury in tube has been balanced by atmospheric pressure at that place.
Value of atmospheric pressure

$$= 1 \text{ bar} = 10^5 \text{ Pa}$$

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53. What physical quantity is measured in torr ? How is it related to the S.I. unit of the quantity.

Ans :
The physical quantity measured in torr is atmospheric pressure. 1 atmosphere (atm)

$$= 0.76 \text{ m of Hg}$$

$$= 1.013 \times 10^5 \text{ Pa}$$

$$1 \text{ torr} = 1 \text{ mm of Hg.}$$

TWO MARKS QUESTIONS

54. State two factors which affect the atmospheric pressure as we go up.

Ans :
Two factors are :
(i) Decrease in height of air column.
(ii) Decrease in density of air.

55. Why is the barometric height used as a unit to express the atmospheric pressure ?

Ans :
The barometric height is used to express the atmospheric pressure because in the relation P

$= h\rho g$, the density of mercury (P) and acceleration due to gravity (g) at a place are constant.

56. How is water drawn up from a well by a water pump ?

Ans :
When a water pump works, the air pressure in the pipe decreases. The atmospheric pressure acting on the water in the well forces the water to rise in the pipe and it is drawn up.

57. Why does our nose start bleeding on high mountains ?

Ans :
At high mountains, the atmospheric pressure is less than the blood pressure. Therefore nose starts bleeding due to excess blood pressure over the atmospheric pressure.

58. Why does a fountain pen leak at high altitude?

Ans :
A fountain pen filled with ink contains some air at the atmospheric pressure on earth's surface. At high altitude, the outside atmospheric pressure falls. The excess pressure inside the rubber tube forces ink to leak out.

59. What is meant by pressure ? State its S.I. unit.

Ans :
Pressure: "The thrust on unit area of the surface is called pressure."

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$$

$$\text{S.I. unit} = \text{Nm}^{-2}$$

60. How does the pressure exerted by a solid and a fluid differ?

Ans :
A solid exerts pressure only on the surface on which it is placed i.e., at its bottom, but a fluid exerts pressure on the bottom as well as on the walls of the container due to its tendency to flow. A fluid, therefore, exerts pressure in all directions.

61. State three factors on which the pressure at a point in a liquid depends.

Ans :
Factors are : (hdg)
(i) h - Depth of the point below free surface.
(ii) d - Density of liquid.
(iii) g - Acceleration due to gravity.

62. State two advantages of an aneroid barometer over a simple barometer.

Ans :
Advantages of aneroid barometer.
(i) It is compact, portable and hence can be carried anywhere.
(ii) It does not contain any liquid and there is no chance of spilling over of liquid as in mercury barometer.

63. How is the reading of a barometer affected when it is taken to (i) a mine, and (ii) a hill ?

Ans :
(i) When barometer is taken in a mine the length of air column increases and pressure increases.
(ii) When barometer is taken to a hill the length of air column decreases and hence atmospheric pressure decreases.

64. Describe a simple experiment to demonstrate that a liquid enclosed in a vessel exerts pressure in all directions.

Ans :
Experiment : We have often seen children playing with polythene bag filled with water and having small holes at various places on this bag and sprinkling water on others. This is because water enclosed in bag exerts pressure in all directions.

65. Name and state the principle on which a hydraulic press works. Write one use of hydraulic press.

Ans :
'Hydraulic press works on the principle of Pascal's law "which states that pressure applied any where on the surface of confined liquid, it is transmitted equally in all directions."
Use : Hydraulic press is used to drill holes in thick metallic sheets.

66. Why does the liquid rise in a syringe when its piston is pulled up?

Ans :
When the piston of a syringe placed in a liquid is pulled up, the pressure inside it becomes less than the atmospheric pressure acting on the liquid. As a result, the atmospheric pressure forces the liquid to rise in the syringe.

67. Explain why a gas bubble released at the bottom of a lake grows in size as it rises to the surface of lake.

Ans :
Bubble released at the bottom of a lake grows in size as it rises to the surface of the lake because the pressure exerted on it by water of the lake decreases hence by Boyles's law PV = constant the volume of bubble increases and the bubble

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grows in size.

68. How will you show that there is vacuum above the surface of mercury in a barometer ? What name is given to this vacuum?

Ans :
If drop of water or alcohol is introduced in the space above mercury column, then the Barometric height drops, as liquid (water or alcohol) vaporises in the vacuum and exerts pressure on the surface of mercury, thereby forcing it down.
The name given to this vacuum is Torricellian vacuum.

69. How is the barometeric height of a simple barometer affected if:
(a) Its tube is pushed down into the trough of mercury?
(b) Its tube is slightly tilted from vertical ?
(c) A drop of liquid is inserted inside the tube?

Ans :
(a) Remains unaffected
(b) Remains unaffected
(c) Decreases

70. What is an altimeter ? State its principle. How is its scale calibrated ?

Ans :
An altimeter is a device used in an aircraft to measure its altitude. It works on the principle that the atmospheric pressure decreases with height above sea level. Its scale is calibrated in terms of height of ascent with height increasing towards left because the atmospheric pressure decreases with increasing of height above the sea level.

71. Differentiate between thrust and pressure.

Ans :

	Thrust	**Pressure**
(i)	Is a vector quantity.	Is a scalar quantity.
(ii)	S.I. unit is (N) newton.	S.I. unit is Nm^{-2}
(iii)	Force acting on whole surface is called thrust.	Thrust acting on unit area is called pressure.

72. Explain the following :
(a) It is easier to cut with a sharp knife than with a blunt one.
(b) Sleepers are laid below the rails.

Ans :
(a) It is easier to cut with a sharp knife than with a blunt one because for the same applied force, area the pressure exerted (force/area) is more in the case of sharp knife than in the case of a blunt one.
(b) Sleepers are laid below the rails to reduce (force/area) pressure on the ground.

THREE MARKS QUESTIONS

73. How does the pressure at a certain depth in sea water differ from that at the same depth in river water ? Explain your answer.

Ans :
We know that, $P = h\rho g$
For the same values of h and g
$P \propto \rho$, the density of the given liquid.
As the density of sea -water is more than that of river - water, therefore, pressure at a certain depth in sea water is more than that at the same depth in river water.

74. A partially inflated balloon is placed inside a bell jar connected to a vacuum pump. On creating vacuum inside the bell jar, balloon gets more inflated. How does the pressure change : increase, decrease or remains same, inside the
(a) bell jar and (b) balloon ?

Ans :
When the vacuum pump creates a vacuum inside the bell jar, the pressure inside the jar decreases. As a result, the pressure inside the balloon, which is partially inflated, becomes greater than the pressure outside the balloon, causing the balloon to expand and become more inflated.

75. Write an expression for the pressure at a point inside a liquid. Explain the meaning of the symbols used.

Ans :
Expression for the pressure at a point inside a liquid : $Pa + hdg$ where Pa is atmospheric pressure, and hdg is pressure due to liquid column.
(h) - depth of the point below the free surface.
(d) - density of liquid
Pressure at a point in a liquid is directly proportional to h and d as 'g' at a place is constant.
(g) is acc. due to gravity
Total pressure in a liquid at depth h
$h = Pa + hdg$

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76. Give two reasons for the use of mercury as a barometric liquid.

Ans :

(i) The density of mercury ($= 13.6 \times 10^3\ \text{kg m}^{-3}$) is greater than that of all other liquids, so only 0.76 m height of mercury column is needed to balance the normal atmospheric pressure. Moreover, the vapour pressure of mercury is negligible, so it does not affect the reading much.

(ii) The mercury neither wets nor does it stick to the glass tube. Therefore it gives the correct reading and can easily be obtained in the pure state.

77. Pressure at the free surface of a water lake is P_1, while at a point at depth h below its free surface is P_2. (a) How are P_1 and P_2 related? (b) Which is more P_1 or P_2 ?

Ans :

(a) Press at the free surface $A = P_1$ (atmospheric pressure only)
Pressure at B at a depth (h) inside lake
$P_2 = P_1$ (atmospheric pressure) + hdg
(pressure due to liquid column)

(b) $P_2 = P_1 + \text{hdg}$
$P_2 > P_1$

78. What do the following indicate in a barometer regarding weather.

(a) Gradual fall in the mercury level,

(b) Sudden fall in the mercury level,

(c) Gradual rise in the mercury level ?

Ans :

(a) Gradual fall in the mercury level indicates fall of pressure. This means moisture is increasing and there is possibility of rain.

(b) Sudden fall in the mercury level shows coming of dust - storm or cyclone.

(c) Gradual rise in mircury level means moisture in air in decreasing. This indicated fair weather.

79. State the laws of liquid pressure.

Ans :

Laws of Liquid Pressure :

(i) Pressure at a point inside the liquid increases with the depth from the free surface.

(ii) Pressure is same at all points in a horizontal plane, in a stationary liquid.

(iii) A liquid seeks its own level.

(iv) Pressure is same in all directions about a point in the liquid.

(v) Pressure at a depth is different in different liquids. It increases with the increase in density of the liquid.

80. Complete the following sentences :

(a) Pressure at a depth h in a liquid of density ρ is.....

(b) Pressure is ..... in all directions about a point in a liquid.

(c) Pressure at all points at the same depth is.....

(d) Pressure at a point inside a liquid is..... to its depth.

(e) Pressure of a liquid at a given depth is..... to the density of liquid.

Ans :

(a) Hpg

(b) Same

(c) The same

(d) Directly proportional

(e) Directly proportional

81. Give two reasons why water is not a suitable barometric liquid.

Ans :

(i) The density of water is low ($= 10^3\ \text{kg m}^{-3}$), so nearly 10.4 m height of water column is needed to balance the normal atmospheric pressure. It will be inconvenient to take a tube of this height for a barometer. Moreover, the vapour pressure of water is high, so the reading becomes inaccurate.

(ii) Water sticks with the glass tube and wets it, so the reading becomes inaccurate.

(iii) Water is transparent, so it surface is not easily seen while taking the observation.

82. Explain the following :

(i) A balloon collapses when air is removed from it.

(ii) Water does not run out of a dropper unless its rubber bulb is pressed.

(iii) Two holes are made in a sealed tin can to take out oil from it.

Ans :

(i) Atmospheric pressure which is more than inside pressure of balloon causes balloon to collapse.

(ii) Atmospheric pressure acting from outside the dropper balances the pressure exerted by water and water does not come out of a dropper. On pressing the dropper inside pressure of water becomes more than outside atmospheric pressure and water runs out.

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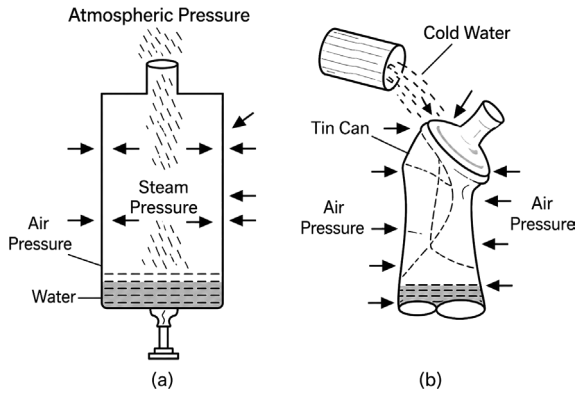
(iii) Two holes are made in a sealed can so that atmospheric air presses the oil at one hole and oil comes out of the second hole.

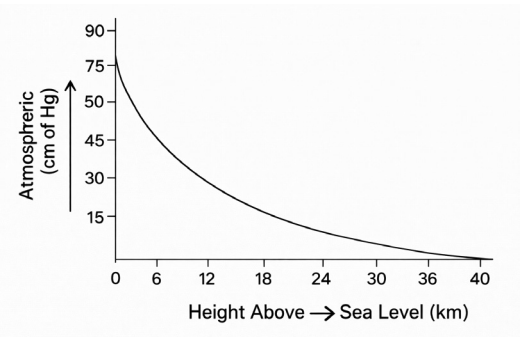
83. Describe an experiment to demonstrate that air exerts pressure.

Ans :
Experiment : Take a tin - can having air tight cap (screw cap). Remove cap and boil some water in it, so that steam comes out and in this way air from inside goes out. While boiling replace the cap and allow it to cool. Vapours inside condense and form water creating vacuum above them. We see the can crumbles due to air pressure from outside. This proves that air exerts pressure.



84. How does the atmospheric pressure change with altitude ? Draw an approximate graph to show this variation.

Ans :
Pressure at sea level is taken as 76 cm of mercury column which is one atmosphere. But his pressure varies with altitude as density of air decreases as we rise up and air becomes rarer. For every 105 m rise in height pressure decreases by 1 cm of mercury column.



Graph shows the approximate variation of pressure with altitude.

85. A tall vertical cylinder filled with water is kept on a horizontal table top. Two small holes A and B are made on the wall of the cylinder, A near the middle and B just below the free surface of water. State and explain your observation.

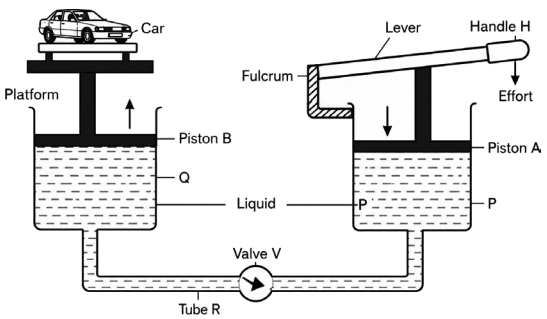
Ans :
I found that the liquid spurts out through each hole and I put my finger on any of the hole, I feel that a thrust due to liquid on the finger. This demonstrates that the liquid contained in the vessel exerts thrust at all points below its free surface. The thrust on unit area at a point gives the pressure due to liquid at that point.
I also notice that as the depth of surface of the liquid decreases the throw of liquid from the hole below the free surface of liquid increases, the liquid reaches to a greater distance on the hotizontal surface. This shows that the liquid pressure at a point increases with the depth of the point from the free surface.

FOUR MARKS QUESTIONS

86. Draw a simple diagram of a hydraulic jack and explain it working.

Ans :
The principle of Pascal's Law is made use in Hydraulic jack.
Explanation : Suppose area of cross-section of piston B is 10 times the area of cross-section of piston A the force with which piston B moves up will be 10 times the force pressing piston A downwards.

$$F_2 = \frac{F_1}{A_1} \times A_2$$



HYDRAULIC JACK

87. What is a barometer ? How is a simple barometer constructed ?

Ans :
Barometer is a device to measure atmospheric

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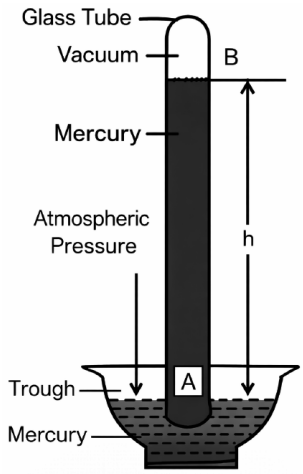
pressure at a place.

To construct a simple barometer : We take a hard glass tube of 1 m long closed at one end having uniform area of cross-section filled completely with pure mercury free from air bubble. Its mouth is closed with thumb. This tube is inverted in trough of mercury, so Trough that no air - bubble enters the tube and tube Mercury is in verticle position, Simple barometer the thumb is removed. In this position mercurry level in the tube falls till the height in tube. above level of mercury in trough is nearly 76 cm. This height is atmospheric pressure at that place. The empty space in tube is called Torricellian vacuum.

88. Explain how is the height of mercury column in the tube of a simple barometer, a measure of the atmospheric pressure.

Ans :

It is seen that at all points such as C on the surface of mercury in trough, only the atmospheric pressure acts. When mercury level in tube becomes



Simple barometer

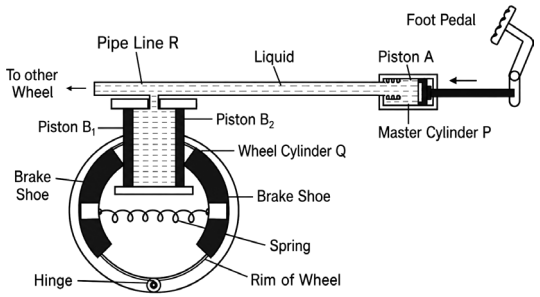
(a)

Stationary, the pressure inside tube at the point A which is at the level of the point C, must be same as that at the point C. The pressure at point A is due to the weight (or thrust) of the mercury column AB above it. Thus, the vertical height of mercury column from the mercury surface in trough to the level in tube, is a measure of the atmospheric pressure.

89. Explain the working of a hydraulic brake with a simple labelled diagram.

Ans :

When we press at A the brake oil moves out of the master cylinder with a certain pressure and, in turn, flows into brake cylinder. In the brake cylinder the pressure gets multiplied and, hence, the brake pistons move outward. In doing so they press the brake shoes tightly against the rotating wheel drum and bring it to rest. At the same time restoring spring develops tension due to outward movement of the brake shoes.



HYDRAULIC BRAKE

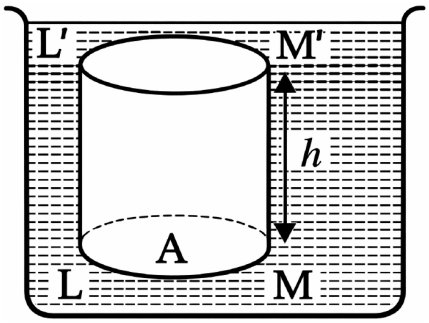
When foot is lifted from brake paddle, the brake oil flows back into master cylinder, making the pistons of brake cylinder move inward.

90. Deduce an expression for the pressure at a depth inside a liquid.

Ans :

Pressure exerted by a liquid column $P = hdg$

Consider a liquid of density (d) and area of portion at bottom (A) and of height (h). Total thrust acting on surface LM is equal to wt. of liquid column $LML'M'$ i.e. thrust exerted on LM = *Wt.* of liquid column $L'M'LM$



= Volume of liquid column $L'M'LM$ $\times$ density $\times$ g

$= (A \times h) \times d \times g$

$= A\,hdg$

$$\text{Pressure} = \frac{\text{Thrust on surface}}{\text{Area of surface}}$$

$$= \frac{A\,hdg}{A}$$

$$P = hdg$$

91. Mention two demerits of a simple barometer and state how they are removed in a Fortin barometer.

Ans :

Defects in simple barometer :

(i) It is not portable as mercury will spill over.

(ii) There is no protection for the glass tube.

(iii) It is quite difficult to keep the barometer tube in verticle position and observations are not correct.

(iv) The free surface of the mercury in the trough does not coincide with the zero mark of the scale fixed to the barometer tube and to get correct reading the trough will have to be moved up or down so as to make zero coincide with free level of mercury in trough.

(v) There are chances that impurities get mixed with mercury intrough.

Removal of defect :

The above quoted defects have been removed in Fortin's barometer as under :

(i) The barometer becomes portable and can be fitted along wall of Laboratory at proper place since trough has been replaced by a leather bag fitted with glass tube for mercury and surrounded by brass cylinder having glass cylinder in the middle which acts as a window.

(ii) The barometer is kept in a vertical position, by holding it with cork having a hole and the whole apparatus is fixed in a rectangular box provided with three glass windows.

(iii) At the bottom of the glass cylinder is fitted with zero adjustment screw which raises or lowers the level of mercury in bowl. An ivory pointer is fitted on the lower side of brass cap for zero adjustment. In this way all the defects of simple barometer are removed.

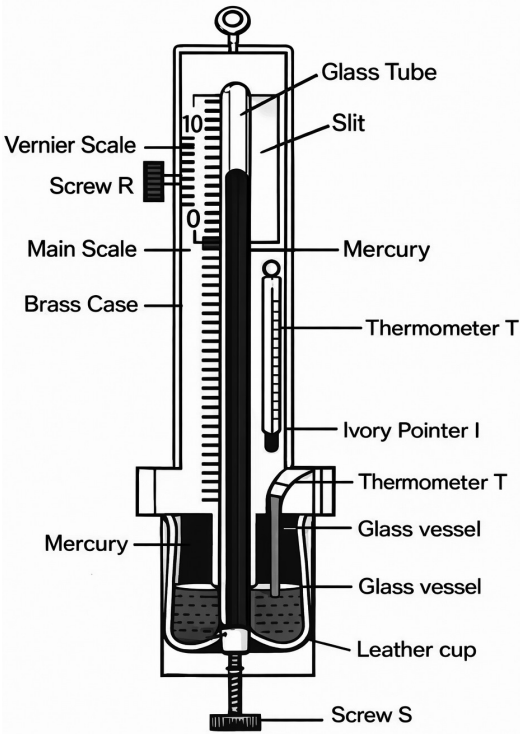
92. Draw a simple labelled diagram of a Fortin barometer and state how it is used to measure the atmospheric pressure.

Ans :

To coincide zero of barometric scale with the free surface of mercury, the zero adjustment screw is moved up or down, till ivory index touches the free surface of mercury.

Now the vernier adjustment screw is moved up or down, till the convex surface of mercury is in line with zero of vernier scale.

At this moment the main scale reading and vernier scale reading are recorded and finally the atmospheric pressure is calculated.

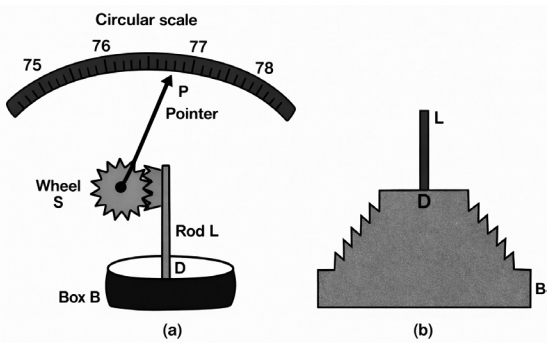


93. What is an aneroid barometer ? Draw a neat and labelled diagram to explain its construction and working.

Ans :

Aneroid means dry hence aneroid barometer is a barometer which does not make use of any liquid. It is handy.

It is partially evacuated box (B) made of corrugated iron sheet acts as diaphragm. A flat spring (k) is connected to a number of levers through a central lever. The tiny moments of central spring are magnified by these levers. The system of levers is further connected with a metallic chain, which passes over a pulley (P). To the pulley is attached a pointer, which moves over a circular scale (S). A hair spring (A) is attached to the pulley which brings the pointer back to its original position.



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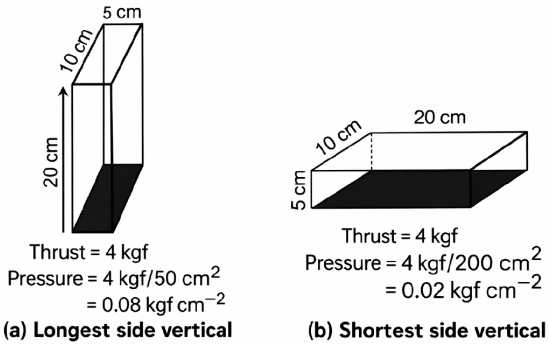
Working : When the atmospheric pressure increases it presses the diaphragm and the central lever moves down. Due to chain pulley and lever system pointer moves to the right over the scale and hair spring gets wound up. When pressure decreases, due to unwinding of hair spring pointer moves in opposite direction to wards the left.

94. How does the pressure exerted by a thrust depend on the area of surface on which it acts ? Explain with a suitable example.

Ans :
Thrust on unit area of the surface is called pressure.

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}} \text{ or } P = \frac{F}{A}$$

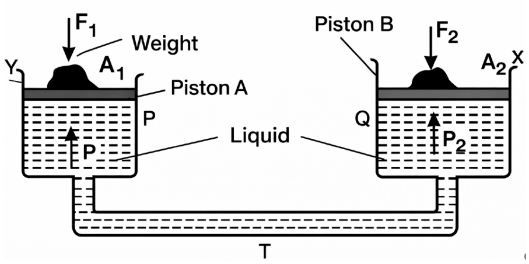
Therefore, pressure depends not only on the force or thrust but also on the area on which the thrust is applied.
Therefore, smaller the area, more is the pressure and vice-versa.
Example : Consider a brick of weight 4 kgf and dimensions 20 cm × 10 cm × 5 cm. It will exert maximum pressure on the ground when it is placed with its 20 cm side vertical as shown in Fig. (a) and it will exert minimum pressure on the ground when it is placed with its 5 cm side vertical as shown in Fig. (b).



It is because the thrust in each case is the same (= 4kgf) but area of the base is minimum in case (a) and maximum in case (b). Therefore, pressure $(\frac{F}{A})$ is maximum in case (a) and minimum in case b).

95. Explain the principle of a hydraulic machine. Name two devices which work on this principle.

Ans :
Consider two cylindrical vessels be connected by a horizontal tube T be filled with water. A_1 and A_2 are the areas of cross - section of water tight pistons Y and X $(A_1 < A_2)$ and force F1 be applied ony y - piston. To keep the piston X in position on force F_2 will have to be applied.



According to Pascal's law

Pressure on $Y = P_1 = \frac{F_1}{A_1}$ and

Pressure on $X = P_2 = \frac{F_2}{A_2}$

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

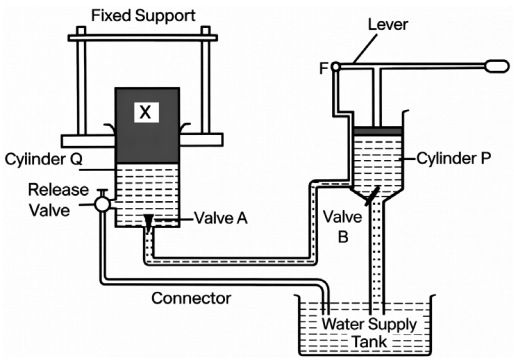
$$F_2 = \frac{A_2}{A_1} \times F_1$$

Since, $A_2 > A_2$

$$F_2 > F_1$$

Thus a small froce F_1 applied on the smaller piston Y can be used to exert a large force F_2 on the bigger piston X.
This is the principle of a hydraulic machine.
Two device are:
(a) Bramah press
(b) Hydraulic brakes.

96. The diagram in figure shows a device which makes use of the principle of transmission of pressure.
(a) Name the parts labelled by the letters X and Y.
(b) Describe what happens to the valves A and B and to the quantity of water in the two cylinders when the lever arm is moved down.



(c) Give reasons for what happens to the valves A and B in part (ii).
(d) What happens when the release valve is opened?

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(e) What happens to the valve B in cylinder P when the lever arm is moved up ?
(f) Give a reason for your answer in part (v).
(g) State one use of the above device.

Ans :
(a) X ..... . Press plunger or RAM
Y ..... . Pump plunger
(b) When the lever arm moves down plump plunger also moves down and valve B closes, valve A opens and quantity of water is transferred from cylinder P into cylinder Q.
(c) Valve B is closed due to increase in pressure in P. Valve A opens as pressure from P is transmitted through connecting pipe to cylinder Q where pressure is less.
(d) Press plunger X gets lowered and water of cylinder Q runs back into supply tank for use again.
(e) Valve B opens as pressure above decreases and allows water from supply tank to move in cylinder P.
(f) Pressure above valve B decreases.
(g) This device is used to extract oil from seeds on large scale.

NUMERICAL QUESTIONS

97. At a given place, a mercury barometer records a pressure of 0.70 m of Hg. What would be the height of water column if mercury in barometer is replaced by water ? Take density of mercury to be $13.6 \times 10^3\ \text{kg m}^{-3}$

Ans :

We know that $P = h\rho g$

$$h_{Hg} \times \rho_{Hg} \times g = h_{water} \times \rho_{water} \times g$$

or $$= h_{water} = h_{Hg} \times \frac{\rho_{Hg}}{\rho_{water}}$$

$$= h_{Hg} \times \text{density of Hg}$$

$$= 0.70 \times 13.6 = 9.52\ \text{m}$$

98. A simple U tube contains mercury to the same level in both of its arms. If water is poured to a height of 13.6 cm in one arm, how much will be the rise in mercury level in the other arm ? Given : density of mercury $= 13.6 \times 10^3$ kg m^{-3} and density of water = 103 kg m^{-3}

Ans :
Press due to mercury column
= Pressure due to water column

$$= h \times 13.6 \times 10^3 \times g$$

$$= \frac{13.6}{100} \times 10^3 \times g$$

$$h = \frac{1}{100}\text{m}$$

$$= \frac{1}{100} \times 100$$

$$= 1\ \text{cm}$$

99. At sea level the atmospheric pressure is 76 cm of Hg. If air pressure falls by 10 mm of Hg per 120 m of ascent, what is the height of a hill where the barometer reads 70 cm Hg. Sate the assumption made by you.

Ans :
Fall in atmospheric pressure

$$= 76\ \text{cm} - 70\ \text{cm}$$

$$= 6\ \text{cm of Hg}$$

Height of ascent when fall of pressure is 10 mm = 120 m
Height of ascent when fall of pressure is 6 cm

$$= \frac{120}{\frac{10}{10}\text{cm}} \times 6\ \text{cm} = 720\ \text{m}$$

Assumption : Atmospheric pressure falls linearly with ascent.

100. Convert 1 mm of Hg into pascal. Take density of $Hg = 13.6 \times 10^3\ \text{kg m}^{-3}$ and $g = 9.8\ \text{ms}^{-2}$

Ans :

Here; $h = 1\ \text{mm}$

$$= 1 \times 10^{-3}\ \text{m of Hg}$$

$$\rho = 13.6 \times 10^3\ \text{kg m}^{-3}$$

$$g = 9.8\ \text{ms}^{-2},$$

$$P = ?$$

Using $P = h\rho g$, we have

$$P = 1 \times 10^{-3} \times 13.6 \times 10^3 \times 9.8\ \text{Pa}$$

$$= 13.6 \times 9.8\ \text{Pa}$$

$$= 133.28\ \text{Pa}$$

101. At sea level, the atmospheric pressure is $1.04 \times 10^5\ Pa$. Assuming $g = 10\ \text{ms}^{-2}$ and density of air to be uniform equal to 1.3 kg m^{-3} 1.3 kg m3, find the height of atmosphere.

Ans :

Here, $P = 1.04 \times 10^5\ \text{Pa}$

$$\rho = 1.3\ \text{kgm}^{-3}$$

$$g = 10\ \text{ms}^{-2}$$

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Using $P = h\rho g$, we have

$$1.04 \times 10^5 = h \times 1.3 \times 10$$

or $$h = \frac{1.04 \times 10^5}{1.3 \times 10}\text{m}$$

$$= 8000\text{ m}$$

102. In a hydraulic machine, a force of 2 N is applied on the piston of area of cross section 10 cm^2. What force is obtained on its piston of area of cross section 100 cm^2 ?

Ans :

Area of cross section of piston 1,

$$A_1 = 10\text{ cm}^2$$

Force applied on it, $F_1 = 2\text{N}$

$$A_2 = 100\text{ cm}^2$$

$$F_2 = ?$$

By the principle of hydraulic machine :

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{2}{10} = \frac{F_2}{100}$$

$$F_2 = \frac{2 \times 100}{10}$$

$$= 20\text{ N}$$

Force on piston of area of cross-section 100 cm^2 is 20N

103. The areas of pistons in a hydraulic machine are 5 cm^2 and 625 cm^2. What force on the smaller piston will support a load of 1250 N on the larger piston ? State any assumption which you make in your calculation.

Ans :

$$A_1 = 5\text{ cm}^2$$

$$F_1 = ?$$

$$A_2 = 625\text{ cm}^2$$

$$F_2 = 1250\text{ N}$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_1 = \frac{F_2}{A_2} \times A_1$$

$$F_1 = \frac{1250 \times 5}{625}$$

$$= 10\text{ N}$$

Assumption made : No friction and no leakage of liquid.

104. Assuming the density of air to be 1.295 kg m^{-3}, find the fall in barometric height in mm of Hg at a height of 107 m above the sea level. Take density of mercury $= 13.6 \times 10^3\text{ kg m}^{-3}$.

Ans :

Let 'PHg' be the pressure due to mercury and 'pair' be the pressure due to air.

Then,

$$P_{Hg} = h_{Hg} \times d_{Hg} \times \text{g}$$

$$= h_{Hg} \times 13600 \times \text{g}$$

and $$P_{air} = h_{air} \times d_{air} \times \text{g}$$

$$= 107 \times 1.295 \times \text{g}$$

Since, $$P_{air} = P_{Hg}$$

$$107 \times 1.295 \times \text{g} = h_{Hg} \times 13600 \times \text{g}$$

[g is a constant]

or $$h_{Hg} = \frac{107 \times 1.295}{13600}$$

$$= 0.010\text{ m or 10 mm}$$

The fall in barometric height is 10 mm.

105. What should be the ratio of area of cross section of the master cylinder and wheel cylinder of a hydraulic brake so that a force of 15 N can be obtained at each of its brake shoe by exerting a force of 0.5 N on the pedal ?

Ans :

Here;

$$F_1 = 0.5\text{ N},$$

$$F_2 = 15\text{ N},$$

$$\frac{A_1}{A_2} = ?$$

Using $$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$, we have

$$\frac{15}{0.5} = \frac{A_2}{A_1}$$

or $$\frac{30}{1} = \frac{A_2}{A_1}$$

or $$\frac{A_1}{A_2} = \frac{1}{30}$$

i.e. ratio of area of cross - section of master cylinder to that of wheel cylinder $= 1:30$

106. The area of base of a cylindrical vessel is 300 cm^2. Water (density = 1000 kg m^{-3}) is poured into it upto a depth of 6 cm. Calculate: (a) the pressure and (b) the thrust of water on the base. (g = 10 m s^{-2}).

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Ans :

(a) Height of water column

$$= 6\,\text{cm} = \frac{6}{100}\,\text{m}$$

Density of water $d = 1000\,\text{kg m}^{-3}$

$$g = 10\,\text{ms}^{-2}$$

$$A = 300\,\text{cm}^2$$

$$= \frac{300}{1000}$$

$$= \frac{3}{100}\,\text{m}^2$$

Pressure, $P = hdg$

$$= \frac{6}{100} \times 1000 \times 10$$

$$= 600\,\text{Pa}$$

(b) Thrust $= P \times A$

$$= 600 \times \frac{3}{100}$$

$$= 18\text{N}$$

107. (a) Calculate the height of a water column which will exert on its base the same pressure as the 70cm column of mercury. Density of mercury is 13.6 g cm^{-3}.

(b) Will the height of the water column in part (a)change if the cross section of the water column is made wider ?

Ans :

(a) $h = ?$

$$P = \frac{70}{100}\,\text{dg of Hg column}$$

$$= \frac{70}{100} \times 13600 \times \text{g}$$

Pressure of water $= \frac{70}{100} \times 13600\,\text{g}$

$$h \times (1000) \times g$$

$$= 70 \times 136\,\text{g}$$

$$h = \frac{70 \times 136}{1000}$$

$$= 9.52\,\text{m}$$

(b) No - pressure does not depend on width of vessel, it depends on depth.

108. The pressure of water on the ground floor is 40,000 Pa and on the first floor is 10,000 Pa. Find the height of the first floor.
(Take: density of water = 1000 kg m^{-3}, g = 10ms^{-2})

Ans :

Difference of pressure

$$= 40000 - 10000$$

$$= 30000\ \text{Pa}$$

Density (d) of water $= 1000\,\text{kg m}^{-3}$,

$$g = 10\,\text{ms}^{-2}$$

$$hdg = 30000$$

$$h \times 1000 \times 10 = 30000$$

h height of 1st floor $= \frac{30000}{100 \times 10}$

$$= 3\text{m}$$

109. What force is applied on a piston of area of cross section 2 cm^2 to obtain a force 150 N on the piston of area of cross section 12 cm^2 in a hydraulic machine ?

Ans :

Let f be the force required on the piston.

Given, for piston $F_1 = f$,

$$A_1 = 2\,\text{cm}^2$$

$$= 2 \times 10^{-4}\,\text{m}^2$$

For Piston $F_2 = 150\,\text{N}$,

$$A_2 = 12\,\text{cm}^2$$

$$= 12 \times 10^{-4}\,\text{m}^2$$

By Pascal's law,

Pressure on Piston (P_1) = Pressure on Piston (P_2)

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

i.e. $\frac{f}{2 \times 10^{-4}} = \frac{150}{12 \times 10^{-4}}$

$$f = \frac{150}{12 \times 10^{-4}} \times 2 \times 10^{-4}$$

$$= \frac{150}{6} = 25\,\text{N}$$

10. A block of iron of mass 7.5 kg and of dimensions 12 cm × 8 cm × 10 cm is kept on a table top on its base of side 12 cm × 8 cm. Calculate : (a) thrust and (b) pressure exerted on the table top. Take 1 kgf = 10 N.

Ans :

Mass of iron block = 7.5 kg

Given, 1 kgf = 10 N

Thrust $(f) = \text{m} \times \text{g}$

$$= 7.5 \times 10$$

$$= 75\ \text{N}$$

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Now, area of table (A)

$$= 12 \times 8$$
$$= 96\,\text{cm}^2$$
$$= 96 \times 10^{-4}\text{m}^2$$
$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$$
$$= \frac{F}{A}$$
$$= \frac{75}{96 \times 10^{-4}}$$
$$= 7812.5\,\text{pa}$$

111. A force of 50 kgf is applied to the smaller piston of a hydraulic machine. Neglecting friction, find the force exerted on the large piston, if the diameters of the pistons are 5cm and 25 cm respectively.

Ans :

$$F_1 = 50\,\text{kgf}$$
$$= (50 \times 10)\,\text{N}$$
$$F_2 = ?$$
$$A_1 = \pi\frac{5}{2} \times \frac{5}{2}$$
$$A_2 = \pi\frac{25}{2} \times \frac{25}{2}$$

Pressure on smaller piston =Pressure on bigger piston

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}, \text{ we have}$$
$$F_2 = F_1\frac{A_2}{A_1}$$
$$= 500 \times \frac{\frac{625}{4}\pi}{\frac{25}{4}\pi}$$
$$F_2 = 500 \times 25\,\text{N}$$
$$= \frac{500 \times 25}{10} = 1250\,\text{kgf}$$

112. Two cylindrical vessels fitted with pistons A and B of area of cross-section 8 cm^2 and 320 cm^2 respectively, are joined at their bottom by a tube and they are completely fillled with water. When a mass of 4 kg of placed on piston A, find: (i) the pressure on piston A, (ii) the pressure on piston B, and (iii) the thrust on piston B.

Ans :

F_1 = force on smaller piston

$A = 4\,\text{kgf} = (4 \times 10\,\text{N})$

F_2 = Force on bigger piston $B = ?$

A_1 is area of cross - section of $A = 8\,\text{cm}^2$

A_2 is area of cross - section of $B = 320\,\text{cm}^2$

(i) Pressure at $A = P_1$

$$= \frac{F_1}{A_1}$$
$$= \frac{40\,\text{N}}{8\,\text{cm}^2}$$
$$= 5\,\text{N cm}^{-2}$$
$$P_1 = \frac{4\,\text{kgf}}{8\,\text{cm}^2}$$
$$= 0.5\,\text{kgf cm}^{-2}$$

(ii) Pressure at $B = P_2$

$$= P_1 = 0.5\,\text{kgf cm}^{-2}$$

Pascal's Law:
"Pressure applied on the surface of confined liquid is equally transmitted in all directions with equal force."

(iii) Thrust on piston

$$B = P \times \text{area}$$
$$= 0.5 \times 320$$
$$= 160\,\text{kgf}$$

113. A hammer exerts a force of 1.5 N on each of the two nails A and B. The area of cross section of tip of nail A is 2 mm^2 while that the nail B is 6 mm^2. Calculate pressure on each nail in pascal.

Ans :

Here;

$$F = 1.5\,\text{N}$$
$$P = ?$$

We know that, $P = \frac{F}{A}$

In the case of nail A;

$$A = 2\,\text{mm}^2$$
$$= 2 \times 10^{-6}\text{m}^2$$
$$P = \frac{1.5}{2 \times 10^{-6}}\text{Nm}^2$$
$$= 0.75 \times 10^6\text{Nm}^{-2}$$
$$= 7.5 \times 10^5\text{Nm}^{-2} \text{ or pascal}$$

In the case of nail B;

$$A = 6\,\text{mm}^2$$
$$= 6 \times 10^{-6}\,\text{m}^2$$
$$P = \frac{1.5}{2 \times 10^{-6}}\text{Nm}^{-2}$$
$$= 2.5 \times 10^5\text{Nm}^{-2}$$
$$= 7.5 \times 10^5\text{Nm}^{-2} \text{ or pascal}$$

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CASE BASED QUESTIONS

114. Priya is observing the sandy bottom of a clear mountain lake having a total water depth of 15 m . She notices an isolated gas bubble forming at the bottom and carefully watches it as it rises vertically to the free surface of the water. She observes that the physical volume of the gas bubble gradually changes during its upward journey. She notes down the atmospheric pressure at the surface as $1.0 \times 105 Pa$ and the uniform density of the lake water as $1000\,\text{kgm}^{-3}$. (Take $g = 10\,\text{ms}^{-2}$).

(a) Calculate the total pressure exerted on the gas bubble when it is exactly at the bottom of the lake.

(b) Describe what happens to the size of the gas bubble as it rises and give one reason for this change.

Ans :

(a) $P_{total} = P_0 + h\rho g$

$= 1.0 \times 105 + (15 \times 1000 \times 10)$

$= 250000\,\text{Pa}$

(b) 1. The physical size of the gas bubble continuously grows larger and its volume increases as it travels upward toward the free surface of the lake.

2. As the bubble rises, the depth of the water column above it decreases, which reduces the total hydrostatic pressure compressing the enclosed gas.

115. Arjun is studying the effect of force and area on a solid surface in his physics laboratory. He uses a solid rectangular metal block of mass 5.0 kg having dimensions 20cm × 10cm × 5cm. He first places the metal block on a flat table such that its largest face is in direct contact with the horizontal surface. After recording his observations, he flips the metal block so that it now rests completely on its smallest face. He measures the thrust and pressure in both orientations to understand their mathematical relationship. (Take $g = 10\,\text{ms}^{-2}$).

(a) Calculate the downward thrust exerted by the metal block on the table.

(b) Calculate the pressure exerted by the metal block when it rests on its largest face.

(c) Calculate the pressure on the smallest face and state how it compares to the largest face.

Ans :

(a) $\text{Thrust} = m \times g$

$:= 5.0\,\text{kg} \times 10\,\text{ms}^{-2}$

$= 50\,\text{N}$

(b) $\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$

$= \frac{50}{0.20 \times 0.10}$

$= 2500\text{Pa}$

(c) 1. $\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$

$= \frac{50}{0.10 \times 0.05}$

$= 10000\,\text{Pa}$

2. The pressure exerted by the smallest face is exactly four times greater than the pressure exerted by the largest face because the contact area is one-fourth the size.

116. Rahul visits a local automobile service station and observes a mechanic lifting a heavy car with ease using a hydraulic jack. He notices that the machine has two cylindrical vessels fitted with watertight pistons of different sizes, connected by a strong horizontal tube containing oil. The mechanic applies a downward force of 150 N on the smaller pump piston, which has an area of cross-section of $0.05\,\text{m}^2$. The larger press piston, supporting the heavy vehicle, has an area of cross-section of $2.5\,\text{m}^2$. Rahul applies his physics knowledge to find the maximum weight the jack can lift.

(a) State the scientific principle on which this specific hydraulic machine works.

(b) Calculate the maximum upward force exerted on the larger piston to lift the car. (3)

Ans :

(a) Pascal's law states that a change in pressure at any point in an enclosed fluid at rest is transmitted equally and undiminished in all directions.

(b) $F_2 = F_1 \times \left(\frac{A_2}{A_1}\right)$

$= 150 \times \left(\frac{2.5}{0.05}\right)$

$= 7500\text{N}$

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117. Meera is working in the school laboratory to understand how atmospheric pressure is practically measured. She sets up an apparatus using pure mercury of density $13600\,\text{kg m}^{-3}$ and records the vertical height of the stationary mercury column as 0.75m. She wonders if she can replace the mercury with water of density $1000\,\text{kg m}^{-3}$ to measure the exact same atmospheric pressure. She mathematically calculates the required height of the water column to see if it is practically feasible to use water inside the standard laboratory room. (Take $g = 10\,\text{ms}^{-2}$).

(a) Calculate the atmospheric pressure recorded by the mercury column.

(b) Calculate the vertical height of the water column required to exert this same atmospheric pressure.

(c) State one physical disadvantage of using water instead of mercury as a barometric liquid.

Ans :

(a) $$P = h \times \rho \times g$$
$$= 0.75 \times 13600 \times 10$$
$$= 102000\,\text{Pa}$$

(b) $$h = \frac{P}{\rho \times g}$$
$$= \frac{102000}{1000 \times 10}$$
$$= 10.2\,\text{m}$$

(c) Water requires a glass tube of approximately 10.4 metres in length, which is extremely long, non-portable, and highly inconvenient to manage inside a standard laboratory.

118. Kavya is travelling with her family in a car to a high-altitude hill station located 3500 m above sea level. During the drive up the steep mountain roads, her grandfather starts experiencing a mild nosebleed. Kavya also notices that the sealed plastic packets of potato chips they bought on the plains have puffed up significantly. She recalls her physics lessons about the weight of the air column and understands that the atmospheric conditions are actively changing as they ascend higher into the mountains.

(a) State what happens to the magnitude of the atmospheric pressure as Kavya travels to the higher altitude.

(b) Give the scientific reason for her grandfather's nosebleed at this high altitude.

(c) Name the specific instrument used in an aircraft to measure altitude based on changing pressure.

(d) State how the density of air changes at higher altitudes compared to the sea level.

Ans :

(a) The atmospheric pressure continuously decreases as Kavya travels to a higher altitude because the vertical height of the air column above her is reduced.

(b) Due to low atmospheric pressure at high altitudes, the internal blood pressure exceeds the outside pressure, forcing blood out of the delicate nasal capillaries.

(c) An altimeter is the specific instrument used in an aircraft to determine the altitude attained by measuring the decrease in the surrounding atmospheric pressure.

(d) The density of air is not uniform; it decreases rapidly and the air becomes significantly more compressed at lower levels compared to higher altitudes.

119. Rohan is assigned a week-long project to monitor the atmospheric pressure in his city using a Fortin barometer installed in the school's meteorological observatory. On Monday, he records a steady and unchanging barometric height. On Wednesday, he observes a sudden and rapid fall in the mercury level within just a few hours. By Friday, the mercury level begins a very gradual rise over the entire day. He matches these pressure variations with the local weather conditions he actively experiences outside the laboratory.

(a) State what the sudden fall in the mercury level on Wednesday indicates about the upcoming weather.

(b) State what the gradual rise in the mercury level on Friday indicates about the changing weather.

(c) State what an absence of any abrupt change in the barometric height indicates.

(d) Name the type of barometer that does not contain any liquid and is easily portable.

Ans :

(a) A sudden fall in the mercury level indicates a rapid decrease in pressure, signalling the rushing of air from surrounding regions and an approaching storm.

(b) A gradual rise in the mercury level indicates that the moisture in the air is decreasing, which directly points towards the possibility of dry weather.

(c) The absence of any abrupt change in the barometric height means the atmospheric pressure is normal, thereby indicating that

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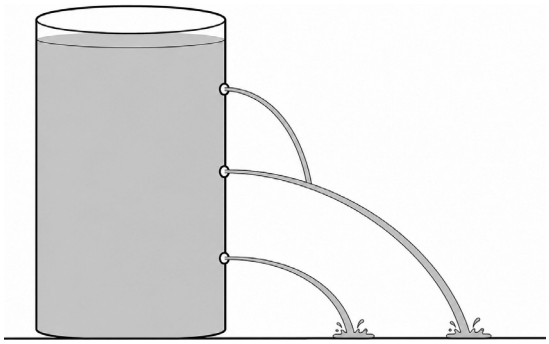
the weather is completely fair.

(d) An aneroid barometer is a compact and portable instrument that operates using a flexible metal box instead of any barometric liquid to measure atmospheric pressure.

120. Vikram is performing a demonstration in his science class to show how pressure varies inside a static fluid. He fills a tall metallic container with water and simultaneously removes the temporary seals from three identical circular openings punched into its vertical side. He strictly measures the horizontal distance travelled by the respective water jets from the container base. The relevant physical observations regarding the fluid flow are immediately recorded in his notebook.



(a) State the relationship between liquid pressure and depth as demonstrated by the bottom hole.

(b) Give one reason why the water jet from the top hole travels the shortest horizontal distance.

(c) State what happens to the throw of the liquid from all holes if water is replaced by a denser liquid like honey. Give one reason.

Ans :

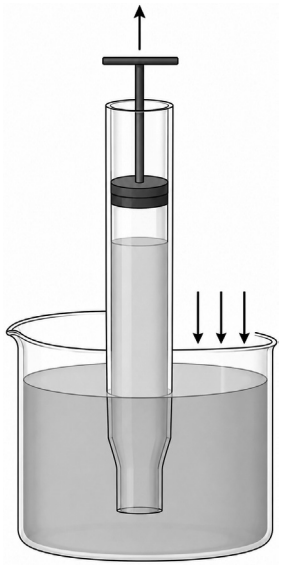
(a) The distance travelled by the bottom jet proves that pressure inside a stationary liquid increases directly with an increase in depth from the free surface.

(b) The top hole is at the minimum depth below the free surface, so it experiences the least hydrostatic pressure, resulting in the weakest outward liquid throw.

(c) 1. The horizontal throw of the liquid from all three holes will increase significantly, reaching a greater distance on the horizontal surface.

2. Liquid pressure is directly proportional to the density of the fluid, so replacing water with a denser liquid exerts a greater outward thrust at all depths.

121. Neha is assisting her science teacher in setting up a biology experiment. She takes a clean plastic medical tool to draw up a colored liquid from a small bottle. She keeps the narrow nozzle fully submerged in the liquid and pulls the top handle upward smoothly. She observes the colored liquid rising steadily inside the hollow barrel against gravity. She maps the internal pressure changes causing the fluid to move.



(a) Identify the physical quantity represented by the downward vertical arrows on the free surface of the liquid.

(b) Give one reason why the pressure inside the barrel becomes less than the outside pressure when the plunger is pulled up.

(c) Calculate the hydrostatic pressure exerted by the drawn liquid column if its height inside the barrel reaches 0.05 m.
(Density of liquid $= 1050\ \text{kgm}^{-3}$, $g = 10\ \text{ms}^{-2}$).

Ans :

(a) The downward arrows represent the atmospheric pressure acting uniformly on the exposed free surface of the liquid in the open beaker.

(b) Pulling the plunger upwards increases the internal volume of the empty barrel, creating a partial vacuum where the air pressure is much less than atmospheric pressure.

(c) 1. Formula: $P = h \times \rho \times g$

2. Substitution: $P = 0.05 \times 1050 \times 10$

3. Result: $P = 525\ \text{Pa}$

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Ans : (C)

Every single commercial maritime shipping vessel explicitly features a clearly painted white reference mark directly located upon its external metallic hull formally known as the Plimsoll line. This critical maritime marking strictly dictates the absolute safe legal limit for loading.

5. A solid object is weighed in air, then in water, and finally in an unknown liquid 'X'.

Medium	Weight (gf)
Air	150
Water	120
Liquid X	126

Based on the data, what is the relative density of liquid X?
(A) 0.80
(B) 0.84
(C) 1.20
(D) 1.25

Ans : (A)

The relative density of a liquid is the ratio of the up-thrust in that liquid to the up-thrust in water. Up-thrust in water = 150 - 120 = 30 gf. Up-thrust in liquid X = 150 - 126 = 24 gf. Therefore, the relative density of liquid X = (Up-thrust in liquid X) / (Up-thrust in water) = 24 / 30 = 0.8.

6. Which of the following fundamental mathematical units is officially universally assigned to formally standardise the precise scientific measurement of relative density?
(A) kg per cubic metre
(B) g per cubic centimetre
(C) Newton per square metre
(D) It has no unit

Ans : (D)

Scientific relative density is strictly mathematically defined exactly as the straightforward numerical ratio directly comparing the true absolute physical density of any tested material perfectly against the standard maximum measured density of pure liquid water recorded at exactly four degrees.

7. Which of the following is the fundamental cause of the buoyant force acting on a completely immersed body?
(A) The density of the body being greater than the fluid
(B) The difference in pressure between the lower and upper surfaces of the body
(C) The atmospheric pressure acting on the free surface of the liquid
(D) The high velocity of the fluid particles surrounding the body

Ans : (B)

Because local hydrostatic liquid pressure effectively predictably increases directly with greater continuous vertical depth, the lower horizontal base of any submerged solid object inherently faces a significantly stronger upward pushing force than the corresponding downward force acting upon the top.

8. A heavy solid metallic block carefully weighed exactly 250 gf in standard air. When completely gently immersed in pure water, it accurately weighed 235 gf. What is the total up-thrust?
(A) 485 gf
(B) 250 gf
(C) 15 gf
(D) 235 gf

Ans : (C)

When a heavy solid object is fully immersed entirely inside a liquid bath, its apparent mathematically measured weight significantly decreases. This specific numerical loss exactly accurately directly corresponds perfectly to the total upward buoyant physical force consistently exerted by fluids.

9. If a stone and a bunch of feathers of equal masses are simultaneously dropped inside a massive glass jar containing a perfect vacuum, what will be visually observed?
(A) The stone falls much faster due to higher density.
(B) Both will fall together safely without any upward up-thrust.
(C) The feathers will float completely due to lack of gravity.
(D) The feathers will fall faster due to maximum up-thrust.

Ans : (B)

Physical upward buoyant fluid forces fundamentally completely strictly naturally inherently permanently rely exclusively directly upon the absolute guaranteed necessary strict continuous complete constant physical presence of an actual external dense material fluid medium to perfectly successfully generate any measurable up-thrust.

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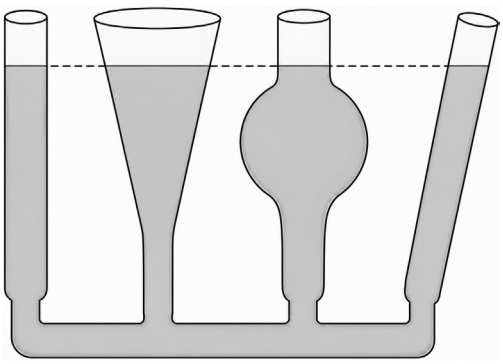
(a) Name the specific arrangement shown in the diagram used to seamlessly transfer the liquid.
(b) State the required condition regarding the air inside the bent tube before the fluid transfer can successfully begin.
(c) Identify the external physical force that originally causes the liquid to rise uphill in the tube from the higher vessel.
(d) State the primary physics reason why the liquid continuously flows down into the lower vessel.

Ans :

(a) The continuous fluid transfer arrangement shown in the diagram is known as a siphon system.
(b) All the air must be completely sucked out or removed from the bent tube to create a lower pressure area before the transfer can begin.
(c) The greater atmospheric pressure acting on the free surface of the liquid in the higher vessel forces the liquid to rise uphill into the tube.
(d) The liquid continuously flows downward because of the difference in hydrostatic liquid pressure between the ends of the tube at the two different vertical levels.

125. Divya is performing an activity to understand how liquids behave in interconnected containers of varying geometric shapes and sizes. She pours a single continuous volume of blue-coloured water into an apparatus consisting of four differently shaped glass tubes that are all joined together at their lowest points by a common horizontal base tube. She waits for the liquid to completely settle and carefully observes the final horizontal water levels.



(a) State the specific law of liquid pressure demonstrated by the liquid reaching the identical vertical height in all four tubes.
(b) State the mathematical effect on the static pressure at the bottom of the second tube if its shape is made twice as wide at the top.
(c) State whether the liquid pressure at the bottom of the narrow first tube is greater than, less than, or perfectly equal to the third tube.
(d) Identify the fluid property that, along with depth and gravity, mathematically determines the pressure at the base of these interconnected tubes.

Ans :

(a) The observation demonstrates the law that a stationary liquid always seeks its own level, meaning pressure is the same at all points on a horizontal plane.
(b) The static pressure at the bottom remains completely unchanged because liquid pressure is totally independent of the shape, size, or cross-sectional area of the vessel.
(c) The liquid pressure at the bottom of the narrow first tube is perfectly equal to the pressure at the bottom of the spherical third tube.
(d) The density of the liquid is the fundamental physical property that, alongside depth and acceleration due to gravity, determines the hydrostatic pressure at the base.

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Relative Density of a Solid by Archimedes' Principle

Relative density

$$= \frac{\text{Mass of a certain volume of substance}}{\text{Mass of same volume of water}}$$

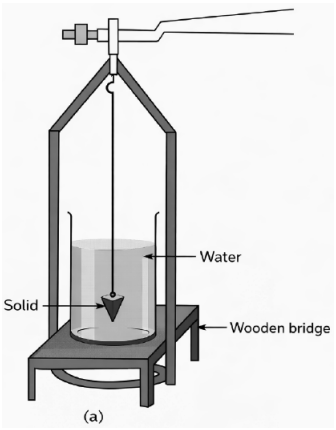
1. According to the Archimedes' principle, the mass of water of volume equal to that of the body is found by finding the mass of water displaced by the body when it is completely immersed in water. Thus, we have

$$\text{R.D} = \frac{\text{Weight of body in air}}{\text{Weight of body in air} - \text{Weight of body in water}}$$

2. If W_1 is the weight of the body in air and W_2 is the weight of the body in water, then

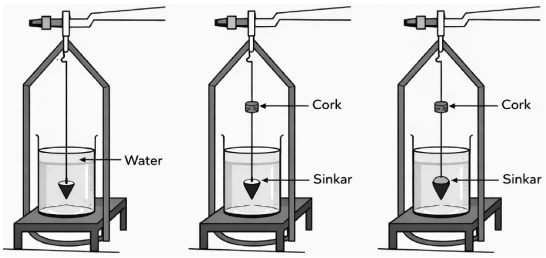
$$\text{R.D.} = \frac{W_1}{W_1 - W_2}$$

Experimental Determination of R.D. of a Solid Denser than Water and Insoluble in it



$$\text{R.D.} = \frac{\text{Weight of solid in air}}{\text{Loss in weight of solid in water}} = \frac{W_1}{W_1 - W_2}$$

Experimental Determination of R.D. of a Solid (Cork) Lighter than Water



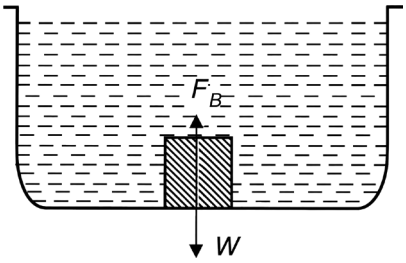
$$\text{R.D. of cork} = \frac{\text{Wight of cork in air}}{\text{Loss in weight of cork in water}} = \frac{W_2 - W_1}{W_2 - W_3}$$

5. FLOATATION AND RELATIVE DENSITY FLOATATION

A body immersed in liquid experiences two forces:

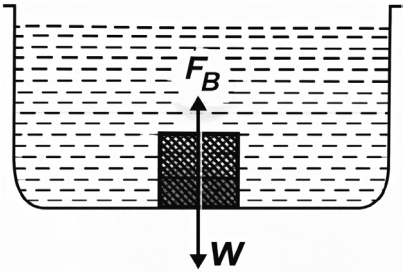
1. Its weight in the downward direction through its centre of gravity G.
2. The up-thrust due to the liquid in the upward direction through the centre of gravity of the displaced liquid. This centre is called the centre of buoyancy B.

Case I: When $W > FB$, i.e., the weight of the body is greater than the weight of the displaced liquid, the body will sink.



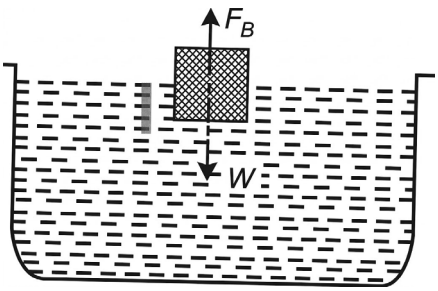
The body sinks when $W > F'_B$

Case II: When $W = FB$, i.e., the weight of the body is equal to the weight of the displaced liquid, the body will float with its body submerged just below the surface of the liquid.



The body floats when $W = F'_B$

Case III: When $W < FB$, i.e., the weight of the body is less than the weight of the liquid displaced, the body will float partially above the surface of the liquid.



The body floats partially inside the liquid when $W < F'_B$ on complete immersion

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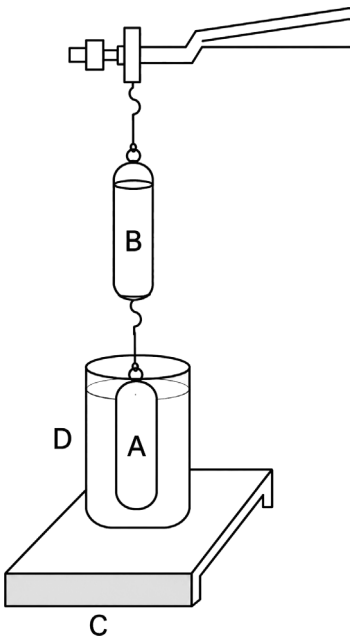
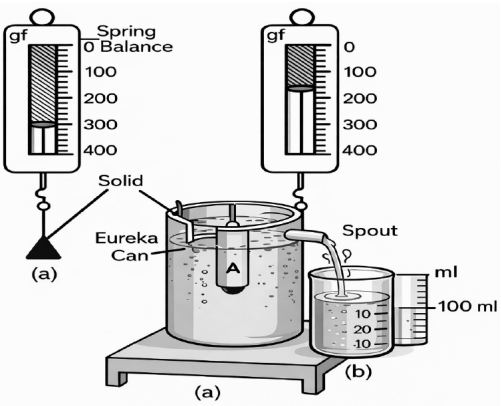
used.



3. The solid cylinder A is immersed in water contained in a beaker D. We observe that the solid cylinder loses some weight, that is, the left arm rises.
4. Water is poured in the hollow cylinder B till it is completely filled. The beam is balanced.
5. Thus, we can conclude that buoyant force acting on the solid cylinder A is equal to the weight of water filled in cylinder B.
6. Because A and B have the same volume, the weight of water in cylinder B is equal to the weight of water displaced by A.
7. Thus, the buoyant force acting on cylinder A is equal to the weight of water displaced by it.

Experiment 2

8. In this experiment, a solid is suspended by a thin thread from the hook of a spring balance. The balance will show a reading.



Verification of Archimedes's principle

9. A can called eureka can filled with water up to the spout is taken. A measuring cylinder is kept near the spout of the can.
10. The solid is gently immersed in the can This leads to spilling of water from the spout which gets collected in the measuring cylinder.
11. Note the weight of the solid and the volume of water collected in the cylinder.
12. Water has density 1 g cm^{-3}. Thus, the volume of water collected in the cylinder is equal to the mass (or weight) of water displaced by the solid.

3. DENSITY

Density of a substance is defined as mass per unit volume.

It is a scalar quantity and is represented by the Greek letter ρ.

$$\rho = \frac{M}{V}$$

Its SI unit is kg m^{-3}, and its CGS unit is g cm^{-3}.

Most substances expand on heating and contract on cooling. Thus, the density of a substance increases with decrease in temperature and decreases with increase in temperature.

4. RELATIVE DENSITY

The relative density of a substance is the ratio of its density to that of water at 4°C.

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$$

$$= \frac{P_s}{P_w}$$

It is also given as the ratio of the mass of the substance to the mass of equal volume of water at 4°C.

$$\text{Relative density} = \frac{\text{Mass of a certain volume of substance}}{\text{Mass of same volume of water}}$$

It has no units because it is a ratio of similar quantities.

In the SI system, the density of water is 1000 kg m^{-3}. Thus, we have

$$\text{R.D} = \frac{\text{Density of a substance}}{100\ \text{kg m}^{-3}}$$

$$\text{Density in kg m}^{-3} = 1000\ \text{R.D}$$

Now, the density of water in the CGS system is g cm^{-3}. Thus, we have

$$\text{R.D} = \frac{\text{Density of a substance}}{1\ \text{g cm}^{-3}}$$

$$\text{Density in g cm}^{-3} = \text{R.D}$$

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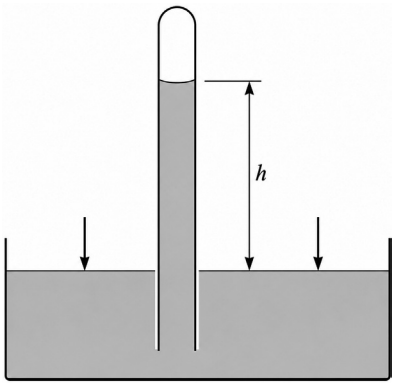
122. Samir is assembling an apparatus to continuously measure atmospheric pressure in his school laboratory. He fills a one-metre-long hard glass tube with a heavy liquid and carefully inverts it into a wide open container filled with the same heavy liquid. He notes that the liquid level inside the tube drops slightly and then becomes completely stationary at a vertical height of 76 cm above the level in the container.



(a) Name the empty gap at the top of the closed tube and state what it contains.

(b) Describe what happens to the vertical height of the liquid column if the glass tube is tilted slightly from its vertical position. Give one reason.

Ans :

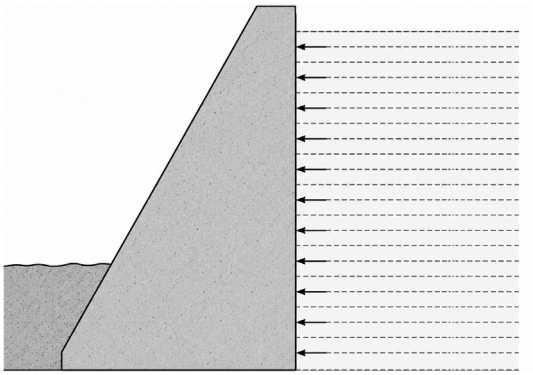
(a) 1. The empty gap created at the closed end of the tube is known as the Torricellian vacuum.

2. This space does not contain air; it only contains a negligible amount of the heavy liquid's vapour.

(b) 1. The vertical height of the liquid column in the tube remains completely unchanged even if the tube is tilted.

2. The atmospheric pressure balancing the column remains constant, and liquid pressure depends only on the vertical depth, not the length of the tilted tube.

123. Ananya is studying the architectural blueprints of a massive hydroelectric dam constructed completely across a deep river valley. She notices that the massive concrete wall holding back the reservoir water has a very distinct cross-sectional shape. The depth of the water near the dam wall reaches a maximum of 120 m. She calculates the hydrostatic pressure at the bottom to thoroughly understand why the structural engineers chose this specific geometric design.



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(a) Calculate the water pressure at the lowest point of the dam where the depth is exactly 120 m. (Take density of water $= 1000\ \text{kgm}^{-3}$, $g = 10\ \text{m s}^{-2}$.

(b) Give one scientific reason why the solid structure is designed to be narrowest at the top and significantly widest at its flat bottom base.

Ans :

(a) 1. Formula: $P = h \times \rho \times g$

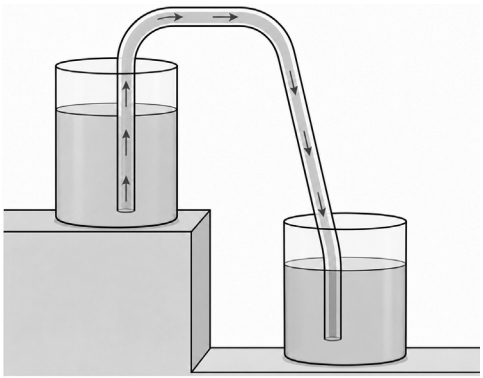
2. Substitution: $P = 120 \times 1000 \times 10$

3. Result: $P = 1200000\ \text{Pa}$

(b) 1. The structure is built thicker at the base because hydrostatic pressure increases directly with the depth of the water from the free surface.

2. A broader bottom wall is absolutely necessary to safely withstand the enormous outward thrust exerted by the water at the maximum depth without collapsing.

124. Karthik needs to transfer a chemical solution from a heavy container kept on a laboratory table to an empty beaker kept on the floor. Instead of manually lifting the heavy container, he uses a bent rubber tube completely filled with the solution to connect the two containers. He ensures the ends are properly submerged and watches the liquid transfer automatically without further assistance.



1. Principle of floatation: The weight of a floating body is equal to the weight of the liquid displaced by its submerged part.

Volume and density of the submerged part of a floating body and the density of liquid

$$\frac{\text{Volume of immersed part of body}}{\text{Volume of body}} = \frac{\text{Density of body}}{\text{Density of liquid}}$$

Applications

2. Floatation of Iron Ship :
   (a) An iron nail sinks in water while a ship floats.
   (b). A ship begins to submerge more as it sails from sea water to river water.
   (c) An unloaded ship is filled with sand at its bottom.
3. Floatation of Man :
   (a) A swimmer fills his lungs with air and keeps his nose and mouth just above the water surface. Thus, the weight of water displaced by the swimmer is nearly equal to his own weight. Thus, he can swim with less effort.
   (b) A man can swim easily in sea water than in fresh water.
4. Floatation of Submarines
5. Floatation of iceberg
   An iceberg floats in water with $1/12^{th}$ part of its total volume above the surface of water.
6. Floatation of fish
7. Rising of balloons

OBJECTIVE QUESTIONS

1. What is the standard SI unit of the up-thrust experienced by a body when immersed in a fluid?
(A) Kilogram
(B) Newton
(C) Pascal
(D) Newton per square metre

Ans : (B)

The upward supportive vertical buoyant physical force actively strongly effectively exerted by an external surrounding dense liquid medium on a submerged heavy body perfectly mathematically physically acts exactly like any standard mechanical force, utilizing the standard newton as its unit.

2. What specific term is mathematically defined as the precise point through which the resultant upward up-thrust strictly acts on an immersed body?
(A) Centre of gravity
(B) Centre of mass
(C) Centre of pressure
(D) Centre of buoyancy

Ans : (D)

The fundamental upward buoyant force continuously exerted by displaced surrounding fluids successfully mathematically resolves directly into a single central resultant upward vector force. This precise centralized resultant vector always perfectly acts vertically upwards directly through the geometric centre of buoyancy.

3. The table shows the densities of four solid objects and two liquids.

Substance	Density (g/cm³)
Object A	0.85
Object B	1.00
Object C	1.04
Object D	1.15
River Water	1.00
Sea Water	1.025

Which object will sink in sea water but float in pure water?
(A) Object A
(B) Object B
(C) Object C
(D) No such object exists in the table.

Ans : (D)

An object sinks if its density is greater than the fluid's density, and floats if it is less. To sink in sea water (1.025 g/cm³), the object's density must be > 1.025 g/cm³. To float in pure water (1.00 g/cm³), its density must be < 1.00 g/cm³. No object can simultaneously have a density greater than 1.025 and less than 1.00.

4. What is the formal specialized name for the visible horizontal safety reference mark explicitly painted directly upon the outer structural metallic hull of massive commercial maritime shipping vessels?
(A) Buoyancy limit
(B) Archimedes mark
(C) Plimsoll line
(D) Floatation border

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CHAPTER 5

Upthrust in Fluids, Archimedes' Principle and Flotation

SUMMARY

1. BUOYANCY AND UP-THRUST

The weight of the object exerts a force on the liquid. The liquid also exerts a certain amount of force on the object in the upward direction. This force is called the buoyant force. The tendency of a liquid to exert an upward force on any object immersed in it is called buoyancy. The upward force exerted by a liquid is also called upthrust.

1.1 Condition for a Body to Sink or Float

1. A body immersed in water experiences two forces - its weight in the downward direction and the upthrust due to water in the upward direction.
2. When $F_B > W$ or $F_B = W$, the body will float. When $F_B > W$, the body will float with a part submerged for which the upthrust is equal to the weight. When $F_B = W$ the body will float with its body completely submerged.
3. When $F_B < W$, the body will sink. It will go down with acceleration equal to difference in both forces divided by its mass.

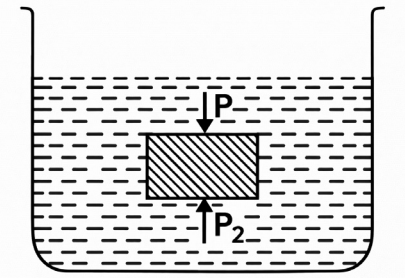
$$a = \frac{W - F_B}{M}$$

1.2 Characteristic Properties of Upthrust

1. Larger the volume of the body submerged in fluid, greater is the upthrust.
2. More the density of fluid, greater is the upthrust.
3. The upthrust acts on the body in the upward direction at the centre of gravity of the displaced fluid which is called the centre of buoyancy.

1.3 Reason for Upthrust

1. The liquid kept in a vessel exerts uniform pressure in all directions.
2. The pressure at a point in a liquid is the same in all directions.
3. It increases with increase in depth.



A block immersed in a liquid

4. The pressure P_2 on the lower face is more than the pressure P_1 on the upper face. This creates a pressure difference between the two faces of the block.
5. Thus, there is a net upward force generated on the block.

$$\text{Upthrust} = F = \frac{P_2 - P_1}{A}$$

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2. ARCHIMEDES' PRINCIPLE

Archimedes' principle: When an object is immersed wholly or partially in a fluid, it experiences an upthrust which is equal to the weight of the fluid displaced by it.

Buoyant force acting on an object = Weight of fluid displaced by that object

Gases however exert a very negligible buoyant force on the objects placed in them.

Experimental Verification of Archimedes' Principle

1. We can verify Archimedes' principle with the help of the following two experiments.

Experiment

2. In this experiment, a solid cylinder A and a hollow cylinder B of the same volume are

10. A massive solid iceberg correctly floating quietly in normal pure liquid water has a measured absolute average physical density of roughly 0.917 g per cubic centimetre. What percentage of it stays underwater?
(A) 8.3 percent
(B) 10.0 percent
(C) 91.7 percent
(D) 100 percent

Ans : (C)

The completely submerged volume fraction of any freely floating object mathematically equals the exact direct ratio of its solid density directly to the surrounding liquid density. For a massive iceberg floating in pure water, slightly over ninety-one percent remains underwater.

11. An object weighs 15.0 N in air. It is then weighed while fully submerged in four different liquids.

Liquid	Relative Density	Apparent Weight (N)
P	0.80	11.0
Q	1.00	10.0
R	1.20	X
S	13.6	Floats

What is the apparent weight 'X' of the object when submerged in liquid R?
(A) 8.0 N
(B) 9.0 N
(C) 11.0 N
(D) 12.0 N

Ans : (B)

From the data for liquid Q (water, R.D. = 1), the up-thrust is 15.0 N - 10.0 N = 5.0 N. Up-thrust is proportional to the density of the liquid. For liquid R with R.D. = 1.2, the up-thrust will be 1.2 times the up-thrust in water, which is 1.2 × 5.0 N = 6.0 N. The apparent weight will be 15.0 N - 6.0 N = 9.0 N.

12. When utilizing Archimedes principle to successfully discover the precise relative density of an insoluble dense solid, which exact specific mathematical formulation must absolutely logically consistently be properly applied?
(A) Weight of body in air / Weight of body in water
(B) Weight of body in air / Apparent loss of weight in water
(C) Apparent loss of weight in water / Weight of body in air
(D) Weight of body in water / Apparent loss of weight in water

Ans : (B)

Following Archimedes fundamental fluid principle, the accurate relative density of a standard physical solid is effectively precisely calculated by dividing its actual total measured downward weight in normal air directly by its apparent physical absolute weight loss inside pure water.

13. The table below, derived from standard data, shows the densities of various substances. One value is represented by the place-holder 'Z'.

Substance	Density (g cm^{-3})	Density (kg m^{-3})
Glass	2.50	2500
Aluminium	2.70	Z
Iron	7.86	7860

What is the correct value for Z?
(A) 27.0
(B) 270
(C) 2700
(D) 27000

Ans : (C)

To convert a density value from g/cm^3 to kg/m^3, one must multiply by 1000. This is because 1 g/cm^3 is equivalent to 1000 kg/m^3. Given the density of Aluminium is 2.70 g/cm^3, its density in SI units will be 2.70 × 1000 = 2700 kg/m^3. The table shows this consistent pattern for glass and iron.

14. Consider the following statements regarding factors that fundamentally affect the total upward upthrust carefully physically exerted by any completely surrounding fluid upon an immersed standard solid body:
I. Volume of the body perfectly submerged in the fluid.
II. The total absolute density of the specific fluid medium.
III. The acceleration due to gravity permanently constantly acting downwards.
IV. The exact fundamental solid material structurally composing the physical body.
Which of the above statements strictly successfully fundamentally successfully accurately directly identify the true factors exactly affecting up-thrust?
(A) I and II only
(B) I, II and IV only

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(C) II, III and IV only
(D) I, II and III only

Ans : (D)

The overall massive absolute magnitude of the active upward strong buoyant environmental force relies heavily continuously exclusively on the specific total volume of the completely physically immersed part of the solid physical body, carefully ignoring the actual solid object material.

15. Why is it naturally significantly physically completely easier for an average human swimmer to successfully effectively float safely inside typical oceanic seawater compared directly to normal flowing fresh river water?
(A) Seawater naturally visibly continuously physically effectively naturally structurally flows at significantly lower dangerous internal physical water currents continually.
(B) Seawater contains dissolved massive heavy dense natural salts effectively drastically increasing its absolute measurable density correctly.
(C) River water heavily naturally accurately constantly contains far significantly less dangerous natural atmospheric dissolved oxygen absolutely.
(D) Seawater heavily directly structurally consistently provides a highly significantly lower overall upward external physical buoyant fluid thrust.

Ans : (B)

Natural heavy oceanic seawater intrinsically effectively contains massive dense quantities of strongly completely dissolved complex mineral salts, reliably consistently making it remarkably measurably completely substantially physically extremely denser than perfectly standard typical completely fresh flowing ordinary river water completely accurately.

ONE MARK QUESTIONS

16. What is the unit of relative density ?

Ans :
Unit of relative density : No units since it is a pure ratio.

17. What can you say about the average density of a ship floating on water in relation to the density of water ?

Ans :
As explained in previous question average density of a ship floating on water is less than that of water.

18. Why is the floating ice less submerged in brine than in water ?

Ans :
It is because the density of brine is more than that of water.

19. A piece of wood if left under water, comes to the surface. Explain the reason.

Ans :
It is because of up-thrust or buoyant force acting on piece of wood.

20. In what direction and at what point does the buoyant force on a body due to a liquid, act ?

Ans :
Buoyant force acts in the upward direction opposite to the direction in which weight of body acts.

21. How is the up-thrust related to the volume of the body submerged in a liquid ?

Ans :
Larger the volume of the body submerged in a liquid, larger is the up-thrust acting on it.

22. "The density of iron is 7800 kg m^{-3}." What do you understand by this statement?

Ans :
This statement means one cubic metre volume of iron has mass of 7800 kg.

23. Define up-thrust and state its S.I. unit.

Ans :
Up-thrust or buoyant force : "When a body is submerged in a fluid the force acting on the body in the upward direction by fluid is called buoyant force.

24. A body experiences an up-thrust F_1 in river water and F_2 in sea water when dipped up to the same level. Which is more F_1 or F_2 ? Give reason.

Ans :
$F_2 > F_1$. Reason : Sea water is more dense than the river water.

25. What do you understand by the term relative density of a substance?

Ans :
Relative density : "is the ratio of density of a Substance to the density of water at 4°C."

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26. Define relative density as a ratio of mass ?

Ans :
Relative density "is the ratio of mass of the substance to the mass of an equal volume of water at 4°C."

27. What is meant by the term buoyancy ?

Ans :
Buoyancy : "The property of a liquid to exert an upward force on a body immersed in it is called Buoyancy".

28. What is the cause of up-thrust ? At which point it can be considered to act ?

Ans :
The cause of up-thrust is the liquid displaced by the body when it is immersed wholly or partially in it. It is considered to be act at the centre of buoyancy i.e., the centre of gravity of displaced fluid.

29. State Archimedes' principle.

Ans :
Archimedes' principle : "Whenever a body is immersed in a liquid (fluid), wholly or partially, it loses weight equal to the weight of liquid displaced by it."

30. Why is a force needed to keep a block of wood inside water?

Ans :
Force is needed to keep a block a wood inside water as the weight of wood is less than weight of water displaced by it i.e., upward thrust acting on wood is greater than gravitational force acting on it.

31. It is easier to lift a heavy stone under water than in air. Explain.

Ans :
Under water a heavy stone experiences up-thrust due to water and feels lighter. So it is easier to lift stone under water.

32. A piece of ice floating in a glass of water melts, but the level of water in glass does not change. Give reason.

Ans :
Ice on melting contracts in volume as the density of ice is less than density of water and ice therefore floats on the surface of water. On melting when vol. decreases, the level of water in the glass does not change.

33. Will a body weigh more in air or in vacuum when weighed with a spring balance ? Give a reason for your answer.

Ans :
A body will weigh more in vacuum than in air since there is no up-thrust acting in vacuum as there is no fluid to be displaced.

34. A piece of ice floating in a glass of water melts, but the level of water in glass does not change. Give reason.

Ans :
Ice on melting contracts in volume as the density of ice is less than density of water and ice therefore floats on the surface of water. On melting when volume decreases, the level of water in the glass does not change.

35. Explain why an iron nail floats on mercury, but it Sinks in water.

Ans :
An iron nail floats on mercury as density of iron is Much less than density of mercury ($7.6\ \text{g cm}^{-3} < 13.6\ \text{g cm}^{-3}$) whereas density of iron is greater than density of water ($7.6\ \text{g cm}^{-3} > 1\ \text{g cm}^{-3}$)and iron nail sinks in water.

36. How does the density of material of a body determine whether it will float or sink in water ?

Ans :
if density of material of body d_B is more than density of liquid d_L i.e. $d_B > d_L$ the body will sink.
On other hand, if $d_L = d_B$ or $d_L > d_B$
The body will FLOAT.

37. Define the term density.

Ans :
Density of a substance is defined as "Mass per unit volume".

$$\text{Density} \qquad [d] = \frac{\text{Mass of the substance}}{\text{Volume of the substance}}$$

$$[d] = \frac{M}{V}$$

38. Write the density of water at 4°C in S.I. unit.

Ans :
Density of water at 4°C is :
1000 kg m^{-3} in S.I.units and
Density of water at 4°C is :
1 g cm^{-3} in C.G.S. units

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(ii) Direction: The direction of up-thrust is always opposite to the direction of gravity. This means that up-thrust always acts in an upward direction, while gravity acts in a downward direction.

(iii) Dependence on Density: The up-thrust is dependent on the density of the fluid. Objects that are less dense than the fluid they are immersed in experience a greater up-thrust than objects that are denser than the fluid. This is because less dense objects displace more fluid than denser objects, and thus experience a greater buoyant force.

70. A man first swims in sea water and then in river water.

(i) Compare the weights of sea water and river water displaced by him.

(ii) Where does he find it easier to swim and why?

Ans :

Density of sea water is greater than density of river water. [Because of impurities]

(i) In each case the weight of water displaced will be equal to the weight of the man.
Ratio of weight of sea water and river water displaced by man is 1 : 1.

(ii) With smaller portion of man's body submerged in sea water, the wt. of sea water displaced is equal to the total weight of body. While to displace the same weight of river water, a larger portion of the body will have to be submerged in water.
It is easier for man to swim in sea water.

71. A body weighs W_1 gf in air and when immersed in a liquid it weighs W_2 gf, while it weighs W_3 gf on immersing it in water. Find : (i) volume of the body (ii) up-thrust due to liquid (iii) relative density of the solid and (iv) relative density of the liquid.

Ans :

$$\text{Wt. of body in air} = W_1$$

$$\text{Wt. of body in liquid} = W_2$$

$$\text{Wt. of body in water} = W_3$$

(i) Volume of the body = Wt. of body in air − Wt. of body in water $= (W_1 - W_2)$ cm3

(ii) Up-thrust due to liquid = Wt. of body in air − Wt. of body in liquid $= (W_1 - W_2)$ gf

(iii) R.D. of the solid

$$= \frac{\text{Wt.of body in air}}{\text{Wt. of body in air} - \text{Wt. of body in water}}$$

$$= \frac{W_1}{W_1 - W_3}$$

(iii) R.D. of the solid

$$= \frac{\text{Wt. of body in air} - \text{Wt. of body in liquid}}{\text{Wt. of body in air} - \text{Wt. of stone in water}}$$

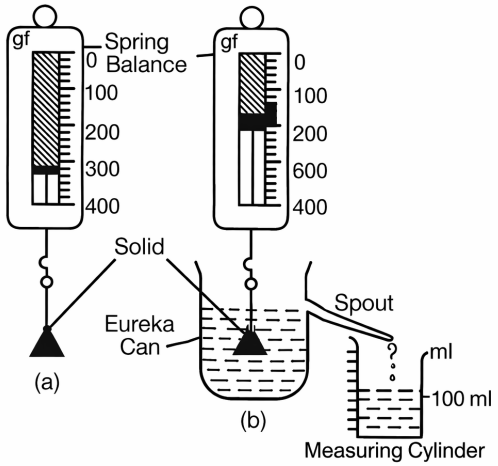
$$= \frac{W_1}{W_1 - W_3}$$

FOUR MARKS QUESTIONS

72. Describe an experiment to show that a body immersed in a liquid appears lighter than it really is.

Ans :

Experiment : Take spring balance and weigh a solid with it as shown in fig. (a).
Let the weight shown by balance be 80 g.
Now immerse the solid in water contained in the beaker. As we lower it in water reading shown by spring balance is less. On further lowering the body in water reading shown will be lesser as shown in fig. (b). On completely dipping the solid, the reading shown by balance will be least. This experiment shows that up-thrust due to liquid is acting on it.



Verification of Archimedes' principle

73. Draw a diagram to show the forces acting on a body floating in water with its some part ubmerged. Name the forces and show their points of application. How is the weight of water displaced by the floating body related to the weight of the body itself ?

Ans :

The forces acting on the body are :

(i) Weight (W) of the body. It acts in the vertically downward direction through the

Ans :
The reason is that the density of glycerine is more than that of water.
This shows that for same volume of a body inside the liquid, a denser liquid exerts greater up-thrust.

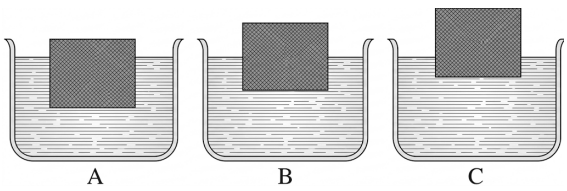
49. A balloon filled with helium gas floats in a big closed jar which is connected to an evacuating pump. What will be your observation, if air from jar is pumped out ? Explain your answer.

Ans :
Observation : The balloon will sink.
Explanation : As the air is pumped out from the jar, the up-thrust on the balloon decreases and becomes zero when jar is evacuated.

50. What is centre of buoyancy ? State its position for a floating body with respect to the centre of gravity of the body.

Ans :
Centre of buoyancy is the centre of gravity of the liquid displaced by the body. The up-thrust (or buoyant force) is equal in magnitude to the weight of the liquid displaced. This force has a tendency to make the body float.

51. Fig. shows the same block of wood floating in three different liquids A, B and C of densities ρ_1, ρ_2 and ρ_3 respectively. Which of the liquid has the highest density ? Give reason for your answer.



Ans :
The block C shows less depth immersed inside the liquid with density ρ_3 is getting maximum up-thrust. Hence liquid with density ρ_3 has highest density.

52. A sphere of iron and another of wood, both of same radius are placed on the surface of water. State which of the two will sink ? Give reason to your answer.

Ans :
Sphere of iron will sink. It is because the density of iron is more than that of water and the density of wood is less than that of water. Therefore, the up-thrust acting on sphere of iron will be less than its weight due to which it will sink. On the other hand, the up-thrust acting on sphere of wood will be more than its weight due to which it will float.

53. What are the units of density in (i) C.G.S. and (ii) S.I. system.

Ans :

$$\text{Density} = \frac{\text{Mass of the substance (M)}}{\text{Volume of the substance (V)}}$$

$$[d] = \frac{1\,\text{g}}{1\text{cm}^3}$$

(i) C.G.S. unit of density is g cm^{-3}

(ii) S.I. unit of density $= \frac{1\,\text{kg}}{1\,\text{m}^3} = \text{Kg m}^{-3}$

NODIA

54. A block of wood is so loaded that it just floats in water at room temperature. What change will occur in the state of floatation, if
(a) some salt is added to water,
(b) water is heated? Give reason.

Ans :
(a) When some salt is added to water, density of water increases. The up-thrust increases due to which the block rises up-to the surface and floats over there. This is the condition when $[w_2 > w_1]$
(b) When water is heated density of water decreases. The block will float with more portion of it inside the water.

55. An iron nail sinks in water while an iron ship floats on water. Explain the reason.

Ans :
Density of iron is more than density of water, weight of iron nail is more than wt. of water displaced by it and nail sinks. While shape of iron ship is made in such a way that it displaces more weight of water than its own weight. Secondly the ship is hollow and the empty space contains air which makes the average density of ship floats on water.

56. What do you understand by the term up-thrust of a fluid ? Describe an experiment to show its existence.

Ans :
Up-thrust : "The upward force exerted on a body by the fluid (liquid or gases) in which it is submerged is called (Up-thrust).
Experiment -
When a piece of wood or cork or sealed empty can is immersed in water it bounces back when released and we feel thrust on our fingers while pushing. This shows that water exerts up-thrust on body.

57. A metal solid cylinder tied to a thread is hanging from the hook of a spring balance. The cylinder is gradually immersed into the water contained in a jar. What changes do you expect in the readings of the spring balance ? Explain your answer.

Ans :
As the cylinder is gradually immersed into the water, volume of water equal to the immersed part is displaced and spring balance gradual decrease in weight till the body is completely immersed and balance shows the least value of weight. This is due to the fact that up-thrust due to water acts in the upward direction.

58. What can you say about the average density of a ship floating on water in relation to the density of water ?

Ans :
Density of iron is more than density of water, weight of iron nail is more than wt. of water displaced by it and nail sinks. While shape of iron ship is made in such a way that it displaces more weight of water than its own weight. Secondly the ship is hollow and the empty space contains air which makes the average density of ship-less than that of water and hence ship floats on water. Average density of a ship floating on water is less than that of water.

THREE MARKS QUESTIONS

59. How are the (i) mass (ii) volume and (iii) density of a metallic piece affected, if at all, with increase in temperature?

Ans :
(i) Mass of a metallic piece remains unchanged with increase in temperature.
(ii) Volume of metal increases with increase in temperature.
(iii) Density : Density of metal decreases as volume increases with increase in temperature

$$\text{Density} = \frac{\text{Mass}}{\text{Vol.}}$$

60. Complete the following sentences
(i) Mass = ... × density
(ii) S.I. unit of density is .....
(iii) Density of water is ..... kg m^{-3}
(iv) Density in kg m^{-3} = ... × density in g cm^{-3}

Ans :
(i) Volume
(ii) kg m^{-3}
(iii) 1000
(iv) 1000

61. A buoy is held inside water contained in a vessel by tying it with a thread to the base of the vessel. Name the three forces that keep the buoy in equilibrium and state the direction in which each forces acts.

Ans :
The three forces that keep the buoy in equilibrium are
(i) Weight of buoy vertically downwards w_1,
(ii) up-thrust of water on buoy vertically upwards w_2, and
(iii) tension in thread vertically downwards T towards the point of suspension.

62. Complete the following sentences :
(a) Two balls, one of iron and the other of aluminium experience the same up-thrust when dipped completely in water if ..... .
(b) An empty tin container with its mouth closed has an average density equal to that of a liquid. The container is taken 2 m below the surface of that liquid and is left there. Then the container will .....
(c) A piece of wood is held under water. The upthrust on it will be ..... the weight of the wood piece.

Ans :
(a) both have equal volume
(b) container will bounce back to the surface
(c) more than.

63. Differentiate between density and relative density of a substance.

Ans :

	Density	**Relative Density**
(i)	It is ratio of mass to volume.	It is ratio of R.D of substance to R.D of water at 4°C.
(ii)	Units are g cm^{-3} or kg m^{-3}	It is a pure quantity. It has no units.
(iii)	Density in kg m^{-3} = R.D × 1000	R.D = Density of g cm^{-3} R.D = $\frac{\text{Density in kg m}^3}{1000}$

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64. How does the density ρ_S of a substance determine whether a solid piece of that substance will float or sink in a given liquid of density ρ_L ?

Ans :

(i) If density of solid ρ_S is greater than density of liquid ρ_L i.e., $\rho_S > \rho_L$
The body will sink.

(ii) If the density of solid ρ_S = density of liquid ρ_L i.e. $\rho_S = \rho_L$
The body will float just inside the liquid.

(iii) If $\rho_S < \rho_L$
The body will float partially above the surface of the liquid and body will get immersed by which the weight of displaced liquid becomes equal to the weight of the body.

65. Water is heated from 0°C to 10°C. How does the density of water change with temperature ?

Ans :

Most of the liquids increase in volume with increase in temperature, but water shows anomalous behaviour. Water has maximum volume at 4°C and maximum density at 4°C.
Actually, when volume increases density .decreases and when volume decreases the density increases. But water when cooled from a high temperature, contracts upto 4°C because volume decreases and expands when cooled further below 4°C and hence density of water increases when it is cooled upto 4°C while decreases when cooled further below 4°C. In other words, the density of water is maximum at 4°C equal to 1 g cm^{-3} or 1000 kg m^{-3}.

66. A body of volume V and density ρ_S, floats with volume v inside a liquid of density ρ_L. Show that $\frac{v}{V} = \frac{\rho_S}{\rho_L}$.

Ans :

Body of vol. V and density ρ_S, floats
Weight of body acting downward $w_1 = V\rho_S g$
Volume v is inside the liquid of density it ρ_L supporting the wt. of whole body
Wt. of liquid displaced by the body

$$w_2 = v\rho_L g$$

Since body is floating

$$w_1 = w_2$$

$$V\rho_S g = v\rho_L g$$

$$V\rho_S g = v\rho_L$$

or $$\frac{v}{V} = \frac{\rho_S}{\rho_L}$$

67. Express the relationship between C.G.S. and S.I. units of density.

Ans :

$$\text{Density} = \frac{\text{Mass}}{\text{Vol}}$$

$$= \frac{1\text{ g}}{1\text{cm}^3} = \text{g cm}^{-3}$$

$$= \frac{1\text{ g}}{1\text{cm}^3} = \frac{1\text{ kg}}{1\text{ m}^3}$$

$$= \frac{1000\text{ g}}{(100 \times 100 \times 100)^3}$$

$$\text{kg m}^{-3} = \frac{1}{1000} = 10^{-3}\text{ g cm}^{-3}$$

or $$1\text{ kg cm}^{-3} = 10^3 = 1000\text{ g cm}^{-3}$$

68. A body weighs W gf in air and W_1 gf when it is completely immersed in water. Find : (i) volume of the body, (ii) up-thrust on the body, (iii) relative density of material of body.

Ans :

Weight of body in air = W gf ...(i)
When completely immersed in water, wt of body W_1 gf ...(ii)
Subtracting,

$$(i) - (ii) = (W - W_1)\text{ gf}$$

(i) Loss in wt. of body in water
= volume of body
$= (W - W_1)\text{ cm}^3$

(ii) Up-thrust on the body
= Loss of wt. of body in water
$= (W - W_1)\text{ gf}$

(iii) R.D. of material of body

$$= \frac{\text{wt. of body in Air}}{\text{wt. of equal vol. of water}}$$

$$= \frac{W}{W - W_1}$$

69. State three characteristic properties of up-thrust.

Ans :

Up-thrust, also known as buoyant force, is the force that acts on an object immersed in a fluid, pushing it upward. The three characteristic properties of up-thrust are:

(i) Magnitude: The magnitude of up-thrust is equal to the weight of the fluid displaced by the object. In other words, the greater the volume of fluid displaced, the greater the up-thrust.

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39. A body of density ρ is immersed in a liquid of density ρ_L. State condition when the body will (i) Float (ii) Sink in liquid.

Ans :
Density of liquid $= \rho_L$
Density of body $= \rho$
(i) It will float if $\rho < \rho_L$ or $\rho = \rho_L$.
(ii) Body will sink in liquid if $\rho > \rho_L$

40. A sphere of iron and another of wood of the same radius are held under water. Compare the up-thrust on the two spheres.

Ans :
Sphere of iron and wood have equal radius :
Have equal volume

Also $V = \frac{4}{3}\pi r^3$

And hence displace equal volume of water = Up-thrust
Have equal up-thrust i.e Ratio of Thrust = 1 : 1

TWO MARKS QUESTIONS

41. A body floats in a liquid with a part of it submerged inside liquid. (i) Is the weight of floating body greater than, equal to or less than up-thrust ? (ii) What is the apparent weight of floating body ?

Ans :
(i) While floating, the weight of a body is equal to the up-thrust.
(ii) The apparent weight of a floating body is zero.

42. Two identical pieces, one of ice (identity = 900 kg m^{-3}) and other of wood (density = 300 km g^{-3}) float on water.
(a) Which of the two will have more volume submerged inside water?
(b) Which of the two will experience more up-thrust due to water?

Ans :
(a) Ice will have more volume submerged inside water.
(b) Ice will experience more up-thrust due to water.

43. 1.A solid iron ball of mass 500 g is dropped in mercury contained in a beaker. (a) Will the ball float or sink ? Give reason. (b) What will be the apparent weight of ball ? Give reason.

Ans :
(a) We know that density iron (7.6 g cm^{-3}) is much less than density of mercury (13.6 g cm^{-3}) Hence when iron ball is dropped in mercury contained in beaker will float.
(b) Floating body shows apparent weight = zero.

44. When a piece of wood is suspended from the hook of a spring balance, it reads 70 gf. The wood is now lowered into water. What reading do you expect on the scale of spring balance ?

Ans :
When the wood is lowered into water the reading shown by spring balance is zero, since density of wood is less than density of water. The floating body appears to have no weight.
Apparent wt = True wt − up-thrust = 0

45. A body dipped into a liquid experiences an up-thrust. State two factors on which up-thrust on the body depends.

Ans :
Two factors are :
(i) Volume of body submerged i.e. greater the volume of the body submerged in the liquid, greater is the up-thrust.
(ii) Density of the liquid : More the density liquid, greater is the up-thrust.

46. A bunch of feathers and a stone of the same mass are released simultaneously in air. Which will fall faster and why? How will your observation be different if they are released simultaneously in vacuum?

Ans :
Stone falls faster as the density of stone is more and volume is less, hence displaces less volume of air.
In vacuum both stone and feather will fall at the same time as there is no fluid to be displaced.

47. A loaded cargo ship sails from sea water to river water? State and explain your observation.

Ans :
We know that density of river water is less than density of sea water. Therefore when ship moves to river water it sinks to larger depth so that more volume of water is displaced so that wt. of displaced water becomes equal to the wt. of ship and ship floats.

48. A small block of wood is held completely immersed in (i) water, (ii) glycerine and then released. In each case, what do you observe ? Explain the difference in your observation in the two cases.

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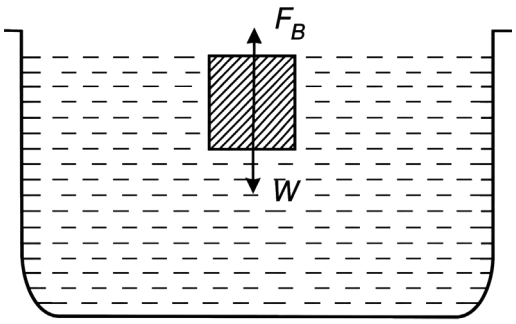
centre of gravity (G) of the body.



The body floats when W = F'B

(ii) Buoyant force (F_B). It acts in the vertically upward direction through the centre of gravity of the displaced liquid i.e. the centre of buoyancy (B).

The weight of floating body = The wt. of liquid displaced by its submerged part.

14. A body of volume V and density ρ is kept completely immersed in a liquid of density ρ_L . If g is the acceleration due to gravity, write expressions for the following :

(i) The weight of the body,
(ii) The up-thrust on the body,
(iii) The apparent weight of the body in liquid,
(iv) The loss in weight of the body.

Ans :

(i) Wt. of body $= mg = V\rho g$

$$\rho = \frac{m}{v}$$
$$m = V\rho$$

(ii) Up-thrust on the body
= Vol. of liquid displaced × density of liquid × gravity
$= V\rho_L g$

(iii) The apparent weight of the body in liquid
= Weight of body − up-thrust
$= V\rho g - V\rho_L g$
$= V(\rho - \rho_L)g$

(iv) The loss in weight of the body
= Weight of body in air − apparent wt. in liquid
$= V\rho g - V(\rho - \rho_L)g$
$= V\rho g - V\rho g + V\rho_L g$
$= V\rho_L g$
= V pg — V (p — pL) g
=Vpg—Vpg+V pLg=V pLg

15. Explain the following :

(a) Icebergs floating in sea are dangerous for ships.
(b) An egg sinks in fresh water, but floats in a strong salt solution.
(c) A toy balloons filled with hydrogen rise to the ceiling, but if filled with carbon dioxide sink to the floor.
(d) As a ship in harbour is being unloaded, it slowly rises higher in water.
(e) A balloon filled with hydrogen rises to a certain height and then stops rising further.
(f) A ship submerges more as it sails from sea water to river water.

Ans :

(a) Icebergs are very dangerous for ships as Icebergs are huge masses of ice floating in sea [density of ice being 0.917 g cm^{-3}] with about $\frac{9}{10}$ portion below water and only $\frac{1}{10}$. portion of it above surface of water.
In fresh water an egg sinks as weight of water displaced by egg is less than its own weight [density of egg being more than water]. But in strong solution of salt, density of water is increased and now weight of water displaced by egg is more than weight of egg and egg floats in salt solution.

(c) We know that density of hydrogen is less than density of air and balloon filled with hydrogen rises as it displaces more wt. of air (up-thrust) than its own wt. Density of CO_2 is more than that of air and balloon filled with CO_2 displaces less wt. of air than wt. of balloon and hence sinks to floor.

(d) On unloading wt. of ship (acting downward) decreases and up-thrust being more, ship rises higher in water.

(e) A balloon filled with hydrogen rises to a certain height as it displaces more wt. of air than wt. of balloon but as it rises higher density of air decreases there and up-thrust becomes less and ultimately up-thrust becomes equal to the weight of balloon and balloon stops rising further.

(f) Density of river water is less than the density of sea water. To balance the weight of ship, a greater volume of water is required to be displaced in water of lower density. So a ship submerges more in river water.

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16. A homogeneous block floats on water (a) partly immersed (b) completely immersed. In each case state the position of centre of buoyancy B with respect to the centre of gravity G of the block.

Ans : -

Ans :

Determination of R.D of solid (heavier than water) by Archimedes' Principle :

Experiment :

1. Take the given solid and suspend it from the L.H.S. hook of physical balance. Place standard weights in the R.H.S. pan and hence find weight of solid.
2. Now place a wooden bridge across the L.H.S. pan of the balance. Place a beaker half filled with water on the bridge and suspend the solid in such a way that it is completely immersed in water. Changes weights in the R.H.S. pan till pointer oscillates equality on either side. Record the weight of solid in water.

Observations and Calculations

1. Weights of solid in air $= \mathrm{M}g$
2. Weight of solid in water $= \mathrm{M}_1 g$
   Loss of wt. of solid in water $= (M - M_1)$ g
   But according to Archimedes' principle :
   Loss of wt. of solid in water = Wt. of water displaced by solid
   Wt. of water displaced by solid $= (M - M_1)$ g
   Also volume of water displaced = Volume of solid
   We know that R.D. of solid

$$= \frac{\text{wt. of solid}}{\text{wt. of an equal volume of water}}$$

R.D. of solid

$$= \frac{\text{wt. of solid in air}}{\text{wt. of water displaced by solid}}$$

R.D. of solid

$$= \frac{\text{wt. of solid in air}}{\text{Loss of wt. of solid in water}}$$

R.D. of solid

$$= \frac{Mg}{(M - M_1)\, g}$$

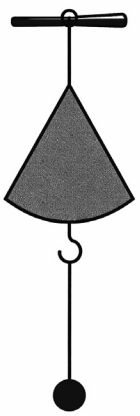
$$= \frac{M}{M - M_1}$$

Modification : If the solid is soluble in water, then we will carry out the experiment in the same way. But then the water will be replaced by the solvent in which the given solid is not soluble.

81. Describe an experiment, using Archimedes' principle, to find the relative density of a liquid.

Ans :

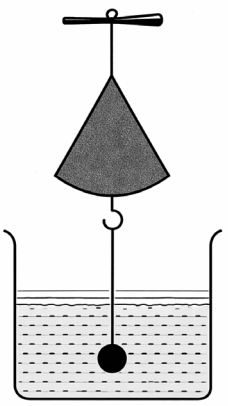
The relative density of a liquid can be found by performing following experiment :



W_1 **in air**

Take a straight meter scale and balance in on the edge of a sharp knife. The metre scale gets balanced at a certain point say 'P' which is its centre of gravity. Take the weight of a solid in air by suspending it at the left side of the balance while a standard weight 'W' is suspended at the right side. The weight is taken by moving the standard weight forward or backward so that the meter scale gets balanced. Let the distance of the solid and the standard weight from the point 'P' be 'd_1' and 'd_2', respectively and the weight of given solid be 'W_1' then according to the law of moments,

$$W_1 \times d_1 = W \times d_2$$



W_2 **in water**

Similarly, the weight of solid is taken in water. Let the new distance between the point 'P' and the standard weigth 'W' be 'd_3' and the weight of solid in water be 'W_2' then according to the law of moments,

$$W_2 \times d_1 = W \times d_3$$

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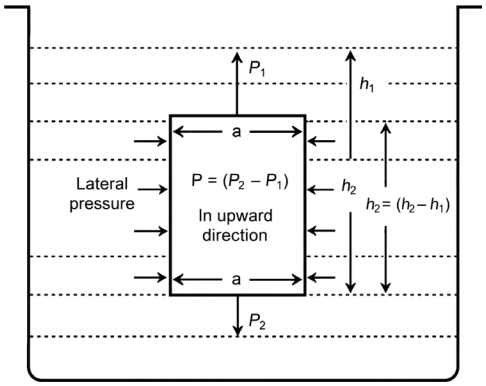
A solid when immersed in a liquid displaces volume of liquid equal to the vol. of immersed portion of solid and loses wt. which is equal to up-thrust [wt. of liquid displaced] or wt of liquid collected in beaker B. Hence loss in wt. of body is equal to Buoyant force.

Up-thrust = Difference in pressure on upper and lower surface



(a) Liquid exert same pressure in all directions at a given depth.

(b) Magnitude of pressure exerted by liquid increases with depth and is given by $-hdg-$

(c) Lateral pressure acting on sides of block cancel each other.

Downward Pressure P_1 on the upper face $= h_1 dg$

Upward Pressure on the lower face

$$P_2 = h_2 dg$$

As $h_2 > h_1$

Net Pressure P in upward direction

$$= (h_2 - h_1)\, dg$$

$$P = hdg$$

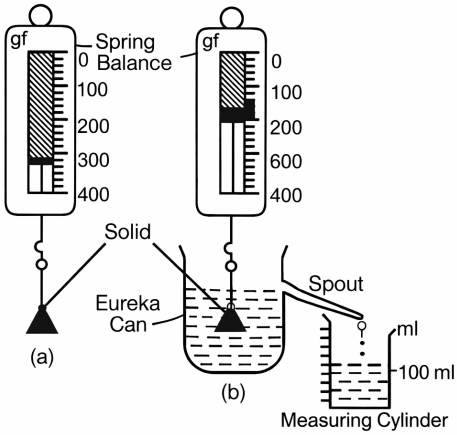
$$h_2 - h_1 = h$$

Up-thrust = Loss in weight of solid in liquid

79. Describe an experiment to verify the Archimedes' principle.

Ans :

Achimede's principle : "Whenever a body is dipped in a liquid wholly or partially, it experiences an up-thrust, which is equal to the weight of the liquid displaced by it."



Verification of Archimedes' principle

Experimental Verification of Archimedes' Law :

(i) Take a clean and dry breaker B and weigh it carefully on a physical balance. Let the weight of empty beaker be = 25 *gf*.

(ii) Take spring balance and suspend it from an iron stand. From its hook suspend a piece of some metal, say Brass. Record the weight. Let it be = 49 *gf*.

(iii) Take a overflow jar and fill it with water, till the water is on verge of overflowing. Place the beaker which is previously weighed, under its spout. Gently lower the solid, suspended from spring balance, into water, in the overflow jar, till whole solid is completely immersed in water.

It is observed the spring balance records lesser value of weight, thereby proving that when a solid is immersed in a fluid it experiences an upthrust. Record the weight of solid in water. Let it be = 49 *gf*.

Apparent loss of weight of solid in water

$$= 49 - 45 = 4\ gf.$$

(iv) On lowering the solid in overflow jar a certain volume of water in it gets displaced. which is equal to volume of solid itself. This displaced water collects in beaker. Weight the beaker B along with water. It will be = 29 *gf*.

Wt. of water displaced by solid $= 29 - 45 = 4\ gf$.

(v) If we compare the weight of water displaced by solid with apparent loss of weight of solid in water. it is found that these weight are equal and = 4 *gf*.

This proves Archimedes' principle.

80. With the use of Archimedes' principle, state how you will find the relative density of a solid denser than water and insoluble in it. How will you modify your experiment if the solid is soluble in water ?

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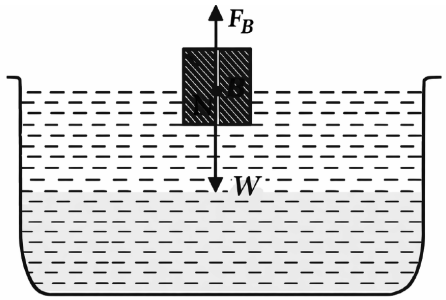
(a) When block floats on water and partly immersed : When $W < F'_B$ i.e., the weight of the body is less than the weight of the liquid displaced by it when it is held completely immersed in the liquid.

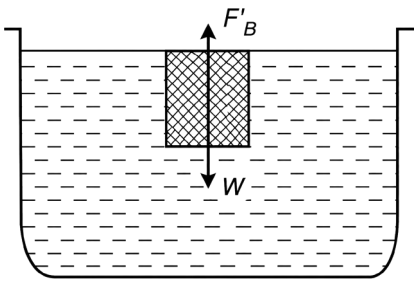
In this case, the body floats partially above and partially below the surface of liquid as shown in the figure. Only that much portion of the body gets submerged by which the weight of displaced liquid becomes equal to the weight of the body. In this situation, while floating, weight W acts at the centre of gravity G of the body, while up-thrust F_B acts at the centre of buoyancy B which is vertically below G, and weight W is equal to up-thrust F_B only due to the submerged part of the body. Thus, the apparent weight of the body will be zero in this case also. The density ρ of such a body is less than the density ρ_L, of liquid (i.e., $\rho < \rho_L$).



The body floats partially inside the liquid when $W < F_B$ on complete immersion

(b) When block floats on water and completely immersed : When $W = F'_B$ i.e., the weight of the body is equal to the weight of the displaced liquid.

In this case, the body will float just below the surface of liquid as shown in figure. The apparent weight of body will be zero. The density ρ of such a body is equal to the density ρ_L of liquid (i.e., $\rho = \rho_L$).



The body floats when $W = F'_B$

17. A body held completely immersed inside a liquid experiences two forces :

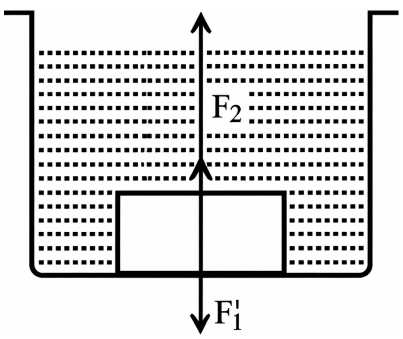
(i) F_1, the force due to gravity and

(ii) F_2, the buoyant force.

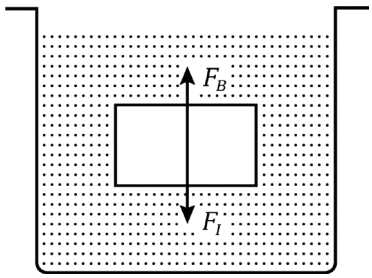
Draw a diagram showing the direction of these forces acting on the body and state condition when the body will float or sink.

Ans :

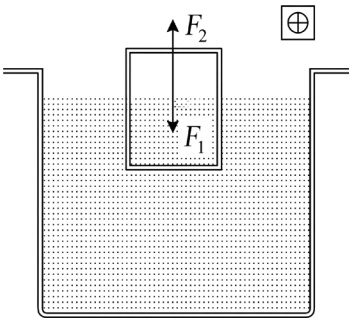
(i) If $F_1 > F_2$the body will sink



(ii) If $F_1 = F_2$ the body will rise to the surface and will float.



(iii) If $F_1 < F_2$ the body will rise to the surface and will float.



18. Prove that the loss in weight of a body when immersed wholly or partially in a liquid is equal to the buoyant force (or up-thrust) and this loss is because of the difference in pressure exerted by liquid on the upper and lower surface of the submerged part of the body.

Ans :

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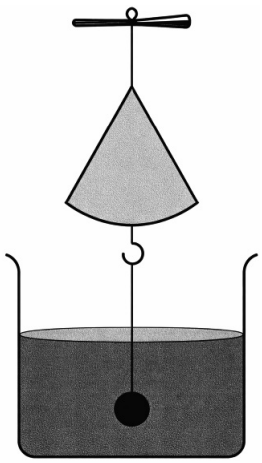


Now, the solid is completely dried and weight is taken immersing it in the given liquid by repeating the above process. Let the new distance between standard weight and point 'P'be 'd_4' and the weight of solid in liquid be 'W_3' then according to the law of moments,

$$W_3 \times d_1 = W \times d_4$$

Observation :

Weight of solid in air $\quad 'W_1' = W \times \frac{d_2}{d_1}$

Weight of solid in water $'W_2' = W \times \frac{d_3}{d_1}$

Weight of solid in liquid $'W_3' = W \times \frac{d_4}{d_1}$

Calculations :

Relative density of liquid

$$= \frac{\text{Apparent loss of weight of solid in liquid}}{\text{Apparent loss of weight of solid in water}}$$

$$= \frac{\text{Weight of solid in air} - \text{Weight of solid in liquid}}{\text{Weight of solid in air} - \text{Weight of solid in water}}$$

$$= \frac{W \times \frac{d_2}{d_1} - W \times \frac{d_4}{d_1}}{W \times \frac{d_2}{d_1} - W \times \frac{d_3}{d_1}}$$

$$= \frac{W \times \left(\frac{d_2}{d_1} - \frac{d_4}{d_1}\right)}{W \times \left(\frac{d_2}{d_1} - \frac{d_3}{d_1}\right)}$$

Relative density of liquid $= \frac{d_2 - d_1}{d_2 - d_3}$

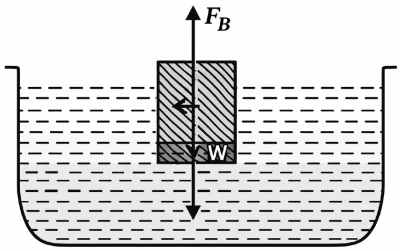
82. A body is held immersed in a liquid. (i) Name the two forces acting on body and draw a diagram to show these forces. (ii) State how do the magni - tudes of two forces mentioned in part (i) determine whether the body will float or sink in the liquid when it is released. (iii) What is the net force on body if it (a) sinks, (b) floats ?

Ans :

When a body is immersed in a liquid, the following two forces act on it :

(i) The weight, W of body acting vertically downwards, through the centre of gravity of body.

(ii) The up-thrust F_B of the liquid acting vertically upwards, through the centre of gravity of displaced liquid, called the centre of buoyancy.

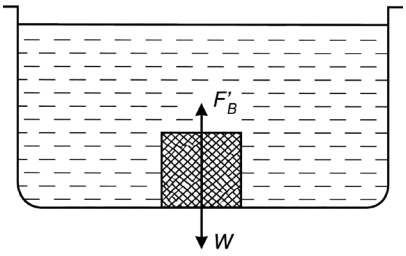


Two forces acting on a floating body

Two forces acting on a floating body

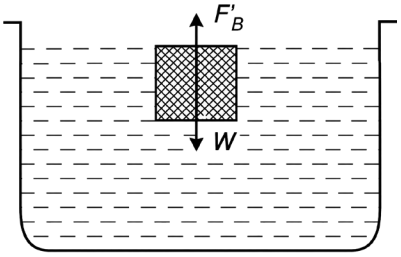
The magnitude of the 2 forces tells whether the body will sink or float.

Case (i) : When $W > F_B$ i.e. the weight of body is greater than the weight of displaced liquid, then body sinks. This is the case when density of solid is greater than that of liquid (i.e. $d > d_L$).



The body sinks when $W > F'_B$

Case (ii) : When $W = F_B$ i.e. the weight of the body is equal to the weight of the displaced liquid, then the body will float just inside the surface of liquid and the density of such a body is equal to density of liquid ($d = d_L$)



The body floats when $W = F'_B$

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96. A jeweller claims that he makes ornament of pure gold of relative density of 19.3. He sells a bangle weighing 25.25 gf to a person. The clever customer weighs the bangle when immersed in water and finds that it weighs 23.075 gf in water. With the help of suitable calculations find out wheter the ornment is made of pure gold or not.

Ans :

R.D. of pure gold = 19.3 (Given)

$$\text{Also R.D} = \frac{\text{weight of bangle in air}}{\text{wt. in air} - \text{wt. of bangle in water}}$$

$$\text{R.D. of gold} = \frac{25.25}{25.25 - 23.075} = \frac{25.25}{2.175}$$

R.D. of gold bangle 11.75 which is not as 19.3
Hence gold is not pure.

97. A rubber ball floats on water with its $1/3^{rd}$ volume outside water. What is the density of rubber ?

Ans :

Let volume of the rubber ball = Vm^3

Density of rubber = $\rho\ \text{kgm}^{-3}$

Density of water = $1000\ \text{kgm}^{-3}$

$$\text{Volume of the ball in water} = \left(V - \frac{V}{3}\right)\text{m}^3$$

$$= \frac{2V}{3}\text{m}^3$$

According to law of floatation,
Weight of the ball = Weight of liquid displaced by it

$$V \times \rho \times g = \frac{2V}{3} \times \text{density of water} \times g$$

$$\rho = \frac{2}{3} \times 1000\ \text{kg m}^{-3}$$

$$= 667\ \text{kg m}^{-3}$$

98. A body of mass 3.5 kg displaces 1000 cm^3 of water when fully immersed inside it. Calculate:
(i) the volume of body,
(ii) the up-thrust on-body and
(iii) the apparent weight of body in water.

Ans :

Mass of body = 3.5 kg $g = 10\ \text{N kg}^{-1}$

(i) Volume of the body
= Volume of water diplaced by it = 1000 cm^3

(ii) Up-thrust on the body
= Weight of water displaced by the body
= Volume of water displaced by the body × density of the body × g

$$= 1000 \times 10^{-6}\text{m}^3 \times 10^3\text{kg m}^{-3} \times 10\ \text{N kg}^{-1}$$

$$= 10\ \text{N}$$

$$= \frac{10}{10}\text{kgf} = 1\ \text{kgf}$$

(iii) Apparent weight of body in water = Weight of body in air − up-thrust

$$= 3.5\ \text{kgf} - 1\ \text{kgf}$$

$$= 2.5\ \text{kgf}$$

99. A body of volume 100 cm^3 weighs 5 kgf in air. It is completely immersed in a liquid of density $1.8 \times 10^3\ \text{kg m}^{-3}$ Find :
(i) the up-thrust due to liquid and
(ii) the weight of the body in liquid.

Ans :

Weight of the body in air = 5 kgf

(i) Up-thrust due to the liquid
= Weight of liquid displaced
= Volume of liquid displaced × density of liquid × g

$$= 100 \times 10 - 6\ \text{m}^3 \times 1.8 \times 10^3\ \text{kg m}^{-3} \times 9.8\ \text{m}^{-2}$$

$$= 0.18 \times 9.8\ \text{N}$$

$$= \frac{0.18 \times 9.8}{9.8}\ \text{kgf} = 0.18\ \text{kgf}$$

(ii) Weight of the body in liquid
= Weight of the body in air − up-thrust
= (5 − 0.18) kgf
= 4.82 kgf

100. A body weighs 450 gf in air and 310 gf when completely immersed in water. Find :
(i) The volume of the body,
(ii) The loss in weight of the body, and
(iii) The up-thrust on the body,
State the assumption made in part (i).

Ans :

Weight of body in air = 450 gf

Weight of body in water = 310 gf

(i) Volume of body
= Volume of water displaced
= Loss of weight of body
= 450 − 310 = 140 cm^3

(ii) The loss in weight of body
= 450 − 310 = 140 gf

(iii) The up-thrust on the body
= Loss in wt. of body
= 450 gf

Assumption made in (i) is that density of water is 1.0g cm^{-3}

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90. Calculate the mass of air in a room of dimensions $4.5\,m \times 3.5\,m \times 2.5\,m$ if the density of air at N.T.P. is 1.3 kg m^{-3}.

Ans :

Volume of air in the room

$= \text{Volume of the room}$

$= 4.5\,m \times 3.5\,m \times 2.5\,m$

$= 39.375 m^3$

Density of air $= 1.3$ kg m^{-3}

$= \text{Volume of air in the room} \times \text{density of air}$

$= 39.375 m^3 \times 1.3\,kg\,m^{-3}$

$= 39.375 \times 1.3$ kg

$= 51.1875$ kg

$= 51.19$ kg

91. A piece of stone of mass 113 g sinks to the bottom in water contained in a measuring cylinder and water level in cylinder rises from 30 ml to 40 ml. Calculate R.D. of stone.

Ans :

Mass of stone $= 113$ g

Volume of stone $= 40\,ml - 30\,ml = 10\,ml$

Density of stone $= \dfrac{\text{mass}}{\text{volume}}$

$= \dfrac{113\,g}{10\,ml}$

$= 11.3$

R.D. of stone $= 11.3$

92. If the density of ice is 0.9 g cm^{-3}, what portion of an iceberg will remain below the surface of water in the sea ? (Density of sea water = 1.1 g cm^{-3})

Ans :

Density of ice $d_S = 0.9\,g\,cm^{-3}$

Density of sea water $d_L = 1.1\,g\,cm^{-3}$

Let V be the volume of iceberg and v the vol. of ice berg inside water

$$\frac{v}{V} = \frac{d_S}{d_L}$$

$$= \frac{0.9}{1.1}$$

$$= \frac{9}{11}$$

Portion of iceberg below the surface of water

$$\frac{v}{V} = \frac{9}{11} \text{ th or } 0.818 \text{ th}$$

93. A piece of wax floats on brine. What fraction of its volume is immersed ?

Density of wax $= 0.95$ g cm^{-3},

Density of brine $= 1.1$ g cm^{-3}.

Ans :

Let V be the vol. of piece of wax

and v' be the vol. of piece inside brine

R.D. of wax $= d_S = 0.95$

R.D of brine $= d_L = 1.1$

$$\frac{v}{V} = \frac{d_S}{d_L} = \frac{0.95}{1.1} = 0.86$$

Fraction of vol. immersed

$$= \frac{v}{V} = 0.86$$

94. A piece of brass weighs 175 gf in air and 150 gf when fully immersed in water. The density of water is 1.0 g cm^{-3}.

(i) What is the volume of the brass piece ?

(ii) Why does the brass piece weigh less in water?

Ans :

Weight of brass piece in air = 175 gf

Weight of brass piece in water = 150 gf

Loss of weight of solid in water

$= (175 - 150) = 25$ gf

(i) Volume of brass piece = 25 cm^3

Density of water is 1 g cm^{-3}

(ii) Brass piece weighs less in water as up-thrust acts on brass piece.

95. A solid weighs 1.5 kgf in air and 0.9 kgf ina liquid of density 1.2×10^3 kg m^{-3}. Calculate the R.D. of solid.

Ans :

Weight of solid in air $= 1.5$ kgf

Weight of solid in liquid $= 1.5$ kgf

Density of liquid $= 1.2 \times 10^3$ kg m^{-3}

$= 12$ g cm^{-3}

R.D. of liquid $= 1.2$

Now R.D. of solid

$$= \frac{\text{Weight of solid in air}}{\text{Loss of weight of solid in liquid} \times \text{R.D. of liquid}}$$

$$= \frac{1.5}{1.5 - 0.9} \times 1.2$$

$$= \frac{1.5}{0.6} \times 1.2$$

$$= 3.0$$

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(ii) Mass of body in air

$$M = 70 \text{ kg}$$

$$\text{Vol. of water displaced} = 20000 \text{ cm}^3$$

$$\text{Vol. of body} = 20000 \text{ cm}^3$$

$$= \frac{20000}{10^6} \text{ m}^3$$

$$V = \frac{2}{100} \text{m}^3$$

$$\text{Density of body} = D = \frac{M}{V}$$

$$= \frac{70}{\frac{2}{100}}$$

$$= 3500 \text{ kg m}^{-3}$$

$$\text{R.D of material of body} = \frac{D}{1000}$$

113. A wooden block floats in water with two - third of its volume submerged. (a) Calculate the density of wood. (b) When the same block is placed oil, three - quarter of its volume is immersed in oil. Calculate the density of the oil.

Ans :

(a) Let vol. of wood $= V$

Vol. of wood submerged

$$v' = \frac{2}{3} V$$

$$\frac{d_S}{d_W} = \frac{v'}{V}$$

$$= \frac{\frac{2}{3} V}{V} = \frac{2}{3}$$

$$d_S = \frac{2}{3}$$

$$d_W = \frac{2}{3} \times 1000$$

$$= 667 \text{ kg m}^{-3} \text{ but}$$

$$d_W = 1000 \text{ kg m}^{-3}$$

Density of wood $d_S = 667 \text{ kg m}^{-3}$

(b) Now $\frac{d_S}{d_L} = \frac{v'}{V}$

$$\frac{\frac{2000}{3}}{d_L} = \frac{\frac{3}{4} V}{V} = \frac{3}{4}$$

$$\frac{2000}{3 d_L} = \frac{3}{4}$$

$$d_L = \frac{2000 \times 4}{3 \times 3}$$

$$= \frac{8000}{9} = 889 \text{ kg m}^{-3}$$

$$\text{Density of oil} = 889 \text{ kg m}^{-3}$$

114. You are provided with a hollow iron ball A of volume 15 cm^3 and mass 12 g and a solid iron ball B of mass 12 g. Both are placed on the surface of water contained in a large tub.

(a) Find up-thrust on each ball.

(b) Which ball will sink? Give reason for you answer. (Density of iron = 8.0 g cm^{-3})

Ans :

(a) $v_1 = 15 \text{ cm}^3$,

$m_1 = 15 \text{ g}$,

Weight of hollow ball .– A in downward direction

$F_1 =$ mass $\times$ acceleration due to gravity $= m_1 g$

$F_1 = 12$ gf

As the ball A floats on the surface of water

It floats with that much part submerged for which up-thrust become 12 gf (its weight)

Up-thrust on ball $A = 12$ gf

When ball A is fully submerged up-thrust acting will be

$$F_2 = vdg$$

$$F_2 = 15 \times 1 \times \text{g}$$

$$F_2 = 15 \text{ gf}$$

$$15 \text{ gf} > 12 \text{ gf}$$

(b) Since $F_2 > F_1$

The ball will float.

For Ball - B

$$m_2 = 12 \text{ g}$$

$$d_2 = 8 \text{ g cm}^{-3}$$

$$v = \frac{\text{mass}}{\text{density}}$$

$$= \frac{12}{8} = 1.5 \text{ cm}^3$$

Wt. of ball $F_1 = m_2$

$g = 12$ gf

Up-thrust on ball B

$$F_2 = vd_2 g$$

$$= 1.5 \times 1g$$

$$= 1.5 \text{ gf}$$

Ball B will sink.

115. A piece of stone of mass 15.1 g is first immersed in a liquid and it weighs 10.9 gf. Then on immersing the piece of stone in water, it weighs 9.7 gf. Calculate :

(a) The weight of the piece of stone in air,

(b) The volume of the piece of stone,

(c) The relative density of stone,

(d) The relative density of the liquid.

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101. A metal cube of edge 5 cm and density 9.0 g cm^{-3} is suspended by a thread so as to be completely immersed in a liquid of density 1.2 g cm^{-3}. Find the tension in the thread. (Take g =10 m s^{-2})

Ans :

Volume of metal cube

$$= (\text{side})^3 = 5^3 = 125 \text{ cm3}$$

Density of cube $= 9$ g cm^{-3}

Weight of cube acting downward $= mg = v \times d$

$$F_1 \downarrow = 125 \times 9$$

$$= 1125 \text{ gf}$$

Density of liquid $d_L = 1.2$ g cm^{-3}

Up-thrust due to liquid in the upward direction.

$$F_2 \uparrow = vd_L$$

$$= 125 \times 1.2$$

$$= 150.0 \text{ gf}$$

Tension in the string = Net downward force

$$= F_1 - F_2 = 1125 - 150$$

$$= 975 \text{ gf}$$

$$= 9.75 \text{ N}$$

102. The density of ice is 0.92 g cm^{-3} and that of sea water is 1.025 g cm^{-3}. Find the total volume of an iceberg which floats with its volume 800 cm^3 above water.

Ans :

R.D of ice $d_S = 0.92$

R.D of sea water $d_L = 1.025$

Let vol. of ice - berg $= V \text{ cm}^3$

Vol. of iceberg above water $= 800 \text{ cm}^3$

$$\frac{(V - 800)}{V} = \frac{d_S}{d_L}$$

$$= \frac{0.92}{1.025} = \frac{184}{205}$$

$$205(V - 800) = 184V$$

$$205V - 184V = 16400$$

$$21V = 16400$$

$$V = 7809.5 \text{ cm}^3$$

103. A piece of wood of uniform cross-section and height 15 cm floats vertically with its height 10 cm in water and 12 cm in spirit. Find the density of (i) wood and (ii) spirit.

Ans :

(i) As the piece of wood has uniform area of cross-section $= a$

$$V = ha$$

$$v' = h'a$$

$$\frac{v'}{V} = \frac{d_S}{d_L}$$

$$\frac{10a}{15a} = \frac{d_S}{1}$$

$$d_S = \text{density of wood}$$

$$= \frac{2}{3} = 0.67 \text{ g cm}^{-3}$$

(ii) Now $\frac{v' = 12 \text{ cm} = 12a}{V = 15 \text{ cm} = 15a} = \frac{d_S}{d_L}$

$$\frac{12}{15} = \frac{\frac{2}{3}}{d_L}$$

$$d_L = \frac{2}{3} \times \frac{15}{12}$$

$$= 0.83 \text{ g cm}^{-3}$$

104. A block of wood is floating on water with its dimensions 50 cm × 50 cm × 50 cm inside water. Calculate the buoyant force acting on the block. Take $g = 9.8$ N kg^{-1}.

Ans :

Volume of water displaced by the block

$$= 50 \text{ cm} \times 50 \text{ cm} \times 50 \text{ cm}$$

$$= 50 \times 50 \times 50 \text{ cm}^3$$

$$= 50 \times 50 \times 50 \times 10^{-6} \text{ m}^3$$

$$= 125 \times 10^{-3} \text{m}^3$$

Density of water $= 10^3$ kg m^{-3}

$g = 9.8$ N kg^{-1}

Buoyant force acting on the block

= Weight of water displaced by the block

= Volume of water displaced by the block

× Density of water × g

$= 125 \times 10^{-3} \times 10^3 \times 9.8 \text{ N} = 1225 \text{ N}$

105. A body of volume 100 cm^3 weighs 1 kgf in air. Find (i) its weights in water and (ii) its relative density.

Ans :

Vol. of body = 100 c.c

Weight of body in air = 1 kg

$f = 10\text{N}$

$mg = 10\text{N}$

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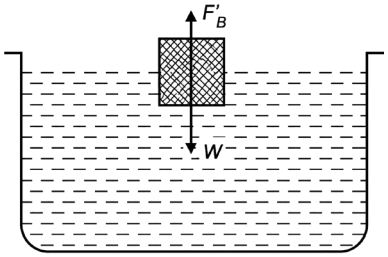
Case (iii) : When $W < F_B$ i.e. the weight of body is less than that of weight of liquid displaced by it, then the body will float partially above the surface of liquid. The density of such a body is less than the density of liquid (i.e. $d < d_L$).



The body floats partially inside the liquid when $W < F'_B$ on complete immersion

NUMERICAL QUESTIONS

83. The relative density of silver is 10.8. Find its density.

Ans :

The R.D of silver is 10.8

$$\text{Density of silver} = \text{R.D.} \times 1000\ \text{kg m}^{-3}$$
$$= 10.8 \times 10^3\ \text{kg m}^{-3}$$

84. The density of copper is 8.83 g cm^{-3}. Express it in kg m^{-3}.

Ans :

$$1\ \text{g cm}^{-3} = 1000\ \text{kg m}^{-3}$$
$$8.83\ \text{g cm}^{-3} = 8.83$$
$$= 8.83 \times 1000$$
$$= 8830\ \text{kg m}^{-3}$$

Density of copper in S.I. unit = 8830 kg m^{-3}.

85. The relative density of mercury is 13.6. State its density in (i) C.G.S. unit, (ii) S.I. unit.

Ans :

RD of mercury = 13.6

Density in

(i) C.G.S units = 13.6 g cm^{-3}

R.D = Density in g cm^{-3}

(ii) S.I. units = 13.6×10^3 kg m^{-3}

Density in kg m^{-3} = R.D × 1000

86. The density of iron is 7.8×10^3kg m^{-3}. What is its relative density?

Ans :

$$\text{The density of iron} = 7.8 \times 10^3 \text{kg m}^{-3}$$
$$\text{R.D of iron} = \frac{\text{Density}}{1000}$$
$$= \frac{7.8 \times 10^3}{10^3} = 7.8$$

87. Calculate the mass of a body whose volume is 2 m^3 and relative density is 0.52.

Ans :

Mass of body $m = ?$

Volume $v = 2\ \text{m}^3$

$\text{R.D} = 0.52$

$\text{Density} = 0.52 \times 1000 \text{kg m}^{-3}$

$= 520\ \text{kg m}^{-3}$

$$\text{Density} = \frac{m}{V}$$

or $m = \text{Vol} \times \text{Density}$

$\text{Mass} = 2 \times 520 = 1040\ \text{kg}$

88. A solid weighs 120 gf in air and 105 gf when it is completely immersed in water. Calculate the relative density of solid.

Ans :

wt. of solid in air = 120 gf

wt, of solid completely dipped in water = 105 gf

Relative density of solid

$$= \frac{\text{wt. in Air}}{\text{wt. in air} - \text{wt. in water}}$$
$$= \frac{120}{120 - 105}$$
$$= \frac{120}{15} = 8$$

89. A body weighs 20 gf in air and 18.0 gf in water. Calculate relative density of the material of the body.

Ans :

Wt. of body in air = 20gf

Wt. of body in water = 20gf

$$\text{R.D of body} = \frac{\text{wt. in air}}{\text{wt. in air} - \text{wt. in water}}$$
$$= \frac{20}{20 - 18}$$
$$= \frac{20}{2} = 10$$

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109. A solid of density 5000 kg m^{-3} weighs 0.5 kgf in air. It is completely immersed in water of density 1000 kg m^{-3}. Calculate the apparent weight of the solid in water.

Ans :

Density of solid, $d_s = 5000$ kg m^{-3}

Weight of body in air $= 0.5$ kgf

$mg = 0.5$ kgf

Volume of solid $V = \frac{m}{d_s}$

$= \frac{0.5}{5000} = \frac{1}{10000}$ m^3

Mass of water displaced

$= V \times D$

$= \frac{1}{10000} \times 1000 = \frac{1}{10}$ kg

Wt. of water $= 0.1$ kg

(i) Apparent weight of the solid in water

$= 0.5 - 0.1 = 0.4$ kgf

(ii) Apparent weight of body in liquid of density 8000 kg m^{-3} is zero

Density of solid is less than density of liquid i.e. up-thrust is more than weight of body.

110. Two spheres A and B, each of volume 100 cm^3 are placed on water (density = 1.0 g cm^{-3}). The sphere A is made of wood of density 0.3 g cm^{-3} and the sphere B is made of iron of density 8.9 g cm^{-3}.

(a) Find :

(i) the weight of each sphere, and

(ii) the up-thrust on each sphere.

(b) Which sphere will float? Give reason.

Ans :

(a)

(i) The weight of sphere $A = V\rho g$

$= 100 \times 0.3 \times g$

$= 30$ gf

The weight of sphere $B = V\rho g$

$= 100 \times 8.9\, g$

$= 890$ gf

(ii) Up-thrust on each sphere

= wt. of liquid displaced

$= V\rho g = 100 \times 1.0\, g$

$= 100$ gf

Sphere A (wood) will float as density of wood (0.3 g cm^{-3}) < water (1.0 g cm^{-3})

111. The mass of a block made of certain material is 13.5 kg and its volume is 15×10^{-3} m^3.

(a) Calculate up-thrust on the block if it held fully immersed in water.

(b) Will the block float or sink in water when released ? Give reason for your answer.

(c) What will be the up-thrust on block while floating?

Take density of water = 1000 kg m^{-3}.

Ans :

(a) Mass of block $m = 13.5$ kg

Vol. of block $= 15 \times 10^{-3}$ m^3

Up-thrust on block when fully immersed in water $= vdg =$ *wt.* of liquid displaced

$= \left(\frac{15}{1000}\right) \times 1000 \times g$

$= 15$ kgf

(b) Density of block

$S = \frac{m}{v}$

$= \frac{13.5}{15 \times 10^{-3}}$

$= \frac{135 \times 1000}{15 \times 10} = 900$ kg m^{-3}

Density of block (900) < density of water (1000 kg m^{-3})

Block will float since density of block is less than density of water

(c) Up-thrust on block while floating = 13.5 kgf

One kgf is the force due to gravity on a mass of 1 kg

Force due to gravity on 13.5 kg = 13.5 kgf

112. A body of mass 70 kg, when completely immersed in water, displaces 20,000 cm^3 of water.

Find :

(i) The weight of body in water and

(ii) The relative density of material of body.

Ans :

(i) Mass of body in water $D = \frac{M}{V}$

M (mass in water)

= Density of water × vol. of body

$= 1000 \times \left(\frac{20000}{1000 \times 1000} m^3\right)$

Mass of body in water $= 20$ kg

Wt. of body in water $= W - V_{dPg}$

$= 700 \times 980 - 20 \times 980$

$= 50$ kgf

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and mass of body $= \frac{10}{g} = \frac{10}{10}$

$= 1 \text{ kg} = 1000 \text{ g}$

Density of body $= \frac{m}{V}$

$= \frac{1000}{100} = 10 \text{ g cm}^{-3}$

R.D of body $= 10$

Vol. of water displaced= vol. body $= 100$ c.c

Up-thrust acting on body $= 100$ gf

Wt. of body in water $= 1000 - 100$

$= 900$ gf

$= \frac{3500}{1000}$

$= 3.5$

106. A solid weighs 32 gf in air and 28.8 gf in water. Find :

(i) The volume of solid

(ii) R.D. of the solid, and

(iii) The weight of solid in a liquid of density 0.9 g cm^{-3}

Ans :

Weight of solid in air $= 32$ gf

Wt. of body in water $= 28.8$ gf

Volume of solid = volume of water displaced

= Loss of wt in water = up-thrust

(i) Vol. of solid $= 32 - 28.8$

$= 3.2 \text{ cm}^3$

(ii) R.D. of solid

$= \frac{\text{wt. of solid in air}}{\text{wt. of solid in air} - \text{wt. of solid in water}}$

$= \frac{32}{32 - 28.8}$

$= \frac{32}{3.2}$

$= 10$

(iii) Now density of liquid $d_1 = 0.9 \text{ g cm}^{-3}$

wt. of solid in this liquid $= 32 - V \times d_1$

$= 32 - 3.2 \times 0.9$

$= 32 - 2.88$

Wt. of solid in liquid $= 29.12$ gf

107. A piece of iron weighs 44.5 gf in air. If the density of iron is 8.9×10^3 kg m^{-3}, find the weight of iron piece when immersed in water.

Ans :

Weight of iron in air $= 44.5$gf

Density of iron $= 8.9 \times 10^3 \text{ kg m}^{-3}$

Relative density of iron $= 8.9$

[Density in kg m-3 = (R.D.) $\times$ 1000]

Let weight or ironin water $= x$

R.D. of iron $= \frac{\text{weight of bangle in air}}{\text{wt. in air} - \text{wt. of bangle in water}}$

$= \frac{44.5}{44.5 - x}$

$= 8.9 = \frac{44.5}{44.5 - x}$

$= 8.9(44.5 - x)$

$= 44.5 = -8.9x$

$= 44.5 - 396.05$

$-x = \frac{-351.55}{8.9}$

$x = 39.5$

Weight of water in iron $= 39.5$ gm

108. A wooden cube of side 10 cm has mass 700 g. What part of it remains above the water surface while vertically floating on the water surface ?

Ans :

Side of cube $= 10$ cm

Volume of cube $V = (10 \times 10 \times 10) \text{ cm}^3$

Mass of wooden cube

$m = 700$g

Density of wood $= D = \frac{m}{V}$

$= \frac{700}{1000}$

$= 0.7$

$D = 0.7 \text{ g cm}^{-3}$

Since density of wood is less than density of water (1 g cm^{-3})

Vol. of wood immersed in water

$= 70\%$ or $\frac{7}{10}$ part.

Vol. of wood outside water

$= 1 - \frac{7}{10} = \frac{3}{10}$ part

$= \frac{3}{10}$ of 10 cm $= 3$ cm

Wooden cube will float in water with 3 cm higher above the water surface.

NODIA

Ans :

Weight of stone = 15.1 g

Weight of stone in liquid = 10.9 gf

Weight of stone in water = 9.7 gf

(a) Weight of the piece of stone in air

= Weight of stone = 15.1 gf

(b) Volume of the piece of stone

= Volume of water displaced

= Loss of wt in water = Up-thrust

Volume of stone = 15.1 − 9.7= 5.4 cm^3

(c) Relative density of stone

$$= \frac{\text{Wt. of stone in air}}{\text{Wt. of stone in air} - \text{Wt. of stone in water}}$$

$$= \frac{15.1}{15.1 - 9.7}$$

$$= \frac{15.1}{5.4} = 2.8$$

(d) Relative density of liquid

$$= \frac{\text{Wt. of stone in air} - \text{Wt. of stone in liquid}}{\text{Wt. of stone in air} - \text{Wt. of stone in water}}$$

$$= \frac{15.1 - 10.9}{15.1 - 9.7}$$

$$= \frac{4.2}{5.4} = 0.78$$

116. A block of wood of mass 24 kg floats on water. The volume of wood is = 0.032 m^3. Find :

(a) The volume of the block below the surface of water,

(b) The density of the wood.

(Density of water = 1000 kg m^{-3})

Ans :

Mass of block of wood $= m = 24$ kg

Vol. of wood $V = 0.032\ m^3$

Density of wood $D = \frac{m}{V} = \frac{24}{0.032}$

$= 750$ kg m^{-3}

$D = 7.5 \times 10^2$ kg m^{-3}

Since density of water = 1000 kg m^{-3}

(a) Vol. of wood inside liquid

$v = ?$

But $\frac{v}{V} = \frac{d_S}{d_L}$

$\frac{v}{0.032} = \frac{750}{1000}$

Density of water = 1000 kg m^{-3}

$v = \frac{750}{1000} \times 0.032$

$v = 0.024\ m^3$

(b) Density of wood $D = 750$ kg m^{-3}

$= \frac{750}{1000} \times 0.032$

$= 7.5 \times 10^2$ kg m^{-3}

117. A weather forecasting plastic balloon of volume 15 m^3 contains hydrogen of density 0.09 kg m^{-3}. The volume of an equipment carried by the balloon is negligible compared to its own volume. The mass of the empty balloon alone is 7.15 kg. The balloon is floating in air of density 1.3 kg m^{-3}. Calculate :

(i) The mass of hydrogen in the balloon,

(ii) The mass of hydrogen and the balloon,

(iii) The total mass of hydrogen, balloon and equipment if the mass of equipment is x kg,

(iv) The mass of air displaced by balloon and

(v) The mass of equipment using the law of floatation.

Ans :

Volume of Hydrogen $V = 15\ m^3$

Density of hydrogen $= d$

$= 0.09$ kg m^{-3}

(i) Mass of hydrogen in balloon

$= Vd$

$= 15 \times 0.09$

$= 1.35$ kg

The mass of empty balloon alone = 7.15 kg

(ii) The mass of hydrogen and balloon

$= 1.35 + 7.15$

$= 8.50$ kg

Mass of equipment $x = x$ kg

(iii) Total mass of hydrogen + Balloon + Equipment

$= (8.50 + x)$ kg

Density of air = 1.3 kg m^{-3}

(iv) Mass of air displaced by ballon

$= v \times d$

$= 15 \times 1.3 = 19.5$ kg

(v) According to law of floatation

Total downward wt. = up-thrust

$8.5 + x = 19.5$

Mass of equipment $x = 11$ kg

NODIA

CASE BASED QUESTIONS

118. Meera is given a solid metal bob weighing 82.1 gf in air. She completely immerses it in water and finds its weight to be 75.5 gf. Her physics teacher then asks her to immerse the same metal bob in a completely different unknown liquid. When Meera suspends the bob fully into the unknown liquid, the spring balance records a reading of 73.8 gf. She records all these observations to determine the relative density of the unknown liquid without directly measuring the volume of the bob.

(a) Calculate the up-thrust experienced by the metal bob when it is completely immersed in the water.

(b) Calculate the up-thrust experienced by the metal bob when it is completely immersed in the unknown liquid.

(c) Calculate the relative density of the unknown liquid using the observations recorded by Meera.

Ans :

(a) Up-thrust in liquid = Weight of body in air - Weight of body in liquid

Upthrust in water = 82.1 gf 75.5 gf

Up-thrust in water = 6.6 gf

(b) Formula : Up-thrust in liquid = Weight of body in air - Weight of body in liquid
Substitution: Up-thrust in liquid
= 82.1 gf - 73.8 gf
Result: Up-thrust in liquid = 8.3 gf

(c) Relative density of liquid
= Up-thrust in liquid / Up-thrust in water
Relative density of liquid = 8.3 gf / 6.6 gf
Result: Relative density of liquid = 1.25

119. Rahul is conducting an experiment to find the relative density of a rock salt lump. He knows that rock salt is soluble in water, so he cannot use water for his measurements. Instead, he chooses turpentine oil, which has a relative density of 0.87. He measures the weight of the rock salt lump in air as 60 gf. After carefully suspending it completely in the turpentine oil, he records its apparent weight as 54 gf.

(a) Give one reason why water is not used to find the relative density of this specific solid material.

(b) Calculate the loss in weight of the rock salt lump when it is completely immersed in the turpentine oil.

(c) Calculate the relative density of the rock salt lump using Rahul's recorded values.

Ans :

(a) Water cannot be used because the rock salt lump is soluble in water, which means it will dissolve before its apparent weight can be properly measured in the laboratory.

(b) Formula : Loss in weight = Weight of solid in air - Weight of solid in liquid
Substitution : Loss in weight = 60 gf - 54 gf
Result : Loss in weight = 6.0 gf

(c) Relative density of solid = (Weight in air / Loss in weight in liquid) × Relative density of liquid
Relative density of solid = (60 / 6) × 0.87
Relative density of solid = 8.7

120. Sneha takes an empty plastic bottle, closes its mouth tightly with an airtight stopper, and places it in a bucket filled with water. She pushes the bottle completely into the water and feels an upward force opposing her push. When she releases the bottle, it immediately bounces back to the surface. She then repeats the exact same procedure by completely immersing the sealed bottle in a bucket filled with glycerine, noting a marked difference in the upward force experienced by her hand.

(a) Name the force that pushes the bottle upwards and state the two factors on which the magnitude of this force depends.

(b) Compare the upward force experienced by the bottle in glycerine with that in water, giving one reason based on fluid properties.

Ans :

(a) 1. The upward force exerted by the fluid on the completely immersed bottle is called the up-thrust or buoyant force.
2. The magnitude of this force depends strictly on the volume of the submerged body and the density of the fluid in which it is submerged.

(b) 1. The bottle experiences a much greater upward force in glycerine as compared to the upward force it experiences when completely immersed in water.
2. This happens because the density of glycerine is significantly higher than the density of water, which proportionately increases the up-thrust exerted on the submerged bottle.

121. Arjun is learning about the floatation of the human body during his physics class. He notes that the average density of a human body with empty

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lungs is 1.07 g cm^{-3}, but it decreases to 1.00 g cm^{-3} when the lungs are filled with air. He travels to the Dead Sea for a vacation and observes that he can easily swim with his shoulders above the water all the time, whereas swimming in his local river required much more effort to stay afloat.

(a) Give two reasons why Arjun finds it easier to float and swim in the Dead Sea compared to the river water.

(b) Describe what happens to the density of a dead human body when submerged underwater over time, and state why it eventually floats.

Ans :

(a) 1. The density of the Dead Sea water is much higher than river water due to a large amount of dissolved salts and minerals present in it.

2. To balance his body weight, Arjun only needs a very small portion of his body submerged in the denser Dead Sea water compared to the river water.

(b) 1. When a dead body is submerged, it decomposes due to gut bacteria, producing gases like methane and hydrogen sulphide which severely decrease the average density of the body.

2. As these trapped decomposition gases expand, the average density of the body becomes lesser than the density of water, causing the body to float upwards to the surface.

122. Rohan fills a large balloon with hydrogen gas, which has a density much less than that of air. He releases the balloon in an open field and observes it rising steadily into the sky. He tracks its movement using binoculars. After reaching a certain high altitude, Rohan notices that the balloon stops rising further and simply floats at that specific height. He records the atmospheric conditions and altitude to understand the vertical forces acting on the balloon at different heights.

(a) State the relationship between the weight of the displaced air and the weight of the gas-filled balloon when it first starts to rise.

(b) Describe what happens to the density of air as the balloon reaches higher altitudes in the atmosphere.

(c) State what happens to the magnitude of the upward force acting on the balloon as it rises higher into the sky.

(d) State the exact condition under which the balloon stops rising and floats at a constant height.

Ans :

(a) When the balloon starts to rise, the weight of the air displaced by the inflated balloon is strictly greater than the total weight of the gas-filled balloon.

(b) As the balloon reaches higher altitudes, the atmospheric pressure drops, causing the density of the surrounding air to gradually decrease as the altitude increases.

(c) Because the density of the surrounding air steadily decreases at higher altitudes, the magnitude of the upward force acting on the balloon also continuously decreases as it rises.

(d) The balloon stops rising further and floats steadily when the decreasing up-thrust exerted by the surrounding air becomes exactly equal to its own total weight.

NODIA

123. Divya visits an aquarium and observes a fish swimming at various depths. She learns that the fish possesses a special internal organ called a swim bladder, which acts like an air-inflated balloon inside its body. Divya notices that when the fish wants to float upwards to the surface, it expands its swim bladder. Later, when the fish needs to dive deeper to the bottom of the tank, it empties its swim bladder to a specific extent.

(a) Describe what happens to the total volume of the fish when its internal swim bladder expands.

(b) State the effect of the expanded swim bladder on the amount of water displaced by the fish.

(c) State the effect on the upward force acting on the fish when it empties its swim bladder to dive down.

(d) Name the scientific principle that dictates the exact upward force experienced by the fish when it is completely immersed.

Ans :

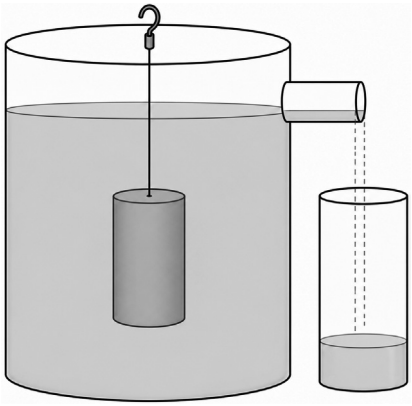
(a) When the internal swim bladder expands and fills with more gas, it significantly increases the total overall volume of the fish's body.

(b) Due to the increased volume of its body, the expanding fish displaces a progressively larger volume of the surrounding aquarium water.

(c) When the fish empties its swim bladder, its volume decreases, which systematically decreases the up-thrust acting on it, allowing it to easily dive deeper.

(d) Archimedes' principle states that the upward force experienced by the fish is always equal to the weight of the liquid displaced by its submerged body.

124. Aditya performs an experiment to find the upward force on a solid iron piece of volume 100 cm^3. He uses a liquid having a density of 1000 kg m^{-3}. The setup includes a container with a side spout and a measuring cylinder placed directly below the spout. The iron piece is lowered into the liquid until it is completely immersed, and the displaced liquid is collected. The acceleration due to gravity is 10 m s^{-2}.



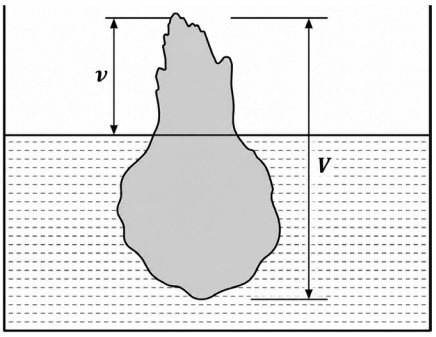
(a) Calculate the magnitude of the upward force acting on the solid iron piece when it is completely immersed in the liquid.
(b) Calculate the mass of the liquid that completely flows through the side spout and collects in the smaller cylindrical container.

Ans :

(a) Formula : Up-thrust
= Volume of solid × Density of liquid × Acceleration due to gravity
Substitution: Up-thrust
= $(100 \times 10^{-6}\ m^3) \times 1000\ kg\ m^{-3} \times 10\ m\ s^{-2}$
Result: Up-thrust = 1.0 N

(b) Formula : Mass of displaced liquid
= Volume of liquid displaced × Density of liquid
Substitution : Mass of displaced liquid
= $(100 \times 10^{-6}\ m^3) \times 1000\ kg\ m^{-3}$
Result : Mass of displaced liquid = 0.1 kg

125. Karthik is studying the dangers that massive ice blocks pose to ships navigating through the ocean. He is given a diagram illustrating one such block floating in seawater. The density of the ice is given as 0.917 g cm^{-3} and the density of the seawater is given as 1.026 g cm^{-3}. He uses the principle of floatation to determine the exact proportion of the total volume that remains hidden below the seawater surface.



(a) Calculate the ratio of the submerged volume to the total volume for the floating object.
(b) Calculate the precise percentage of the object's volume that remains completely exposed above the surface of the seawater.
(c) Name the principle that states the weight of the floating object is exactly equal to the weight of the liquid displaced by its submerged part.

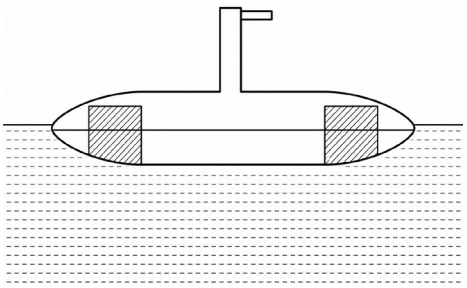
Ans :

(a) Formula : Ratio (submerged volume / total volume)
= Density of solid object / Density of liquid
Substitution:
Ratio (v/V) = 0.917 g cm^{-3} / 1.026 g cm^{-3}
Result: Ratio (v/V) = 0.893 (or 89.3%)

(b) Formula : Percentage above surface
= 100% - Percentage submerged
Substitution: Percentage above surface
= 100% - 89.3%
Result : Percentage above surface = 10.7%

(c) The principle of floatation states that a floating body entirely displaces its own weight in the fluid in which it floats.

126. Priya is researching marine vessels that can travel both on the surface of the sea and deep underwater. She examines a cross-sectional diagram of a specific vessel equipped with internal tanks designed to control its vertical movement. She observes how the vessel dives into the water by completely filling these tanks and rises to the surface by using compressed air to force the water out of the tanks into the sea.



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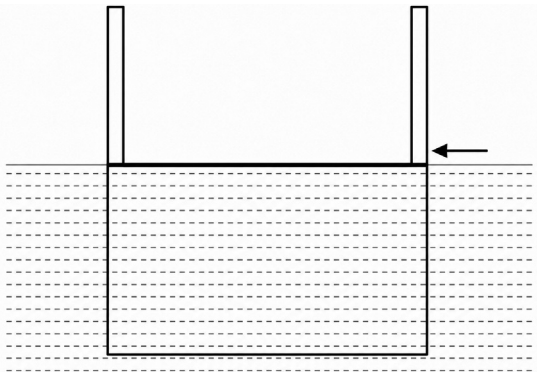
(a) Name the two rectangular compartments located inside the main body of the marine vessel.
(b) Describe what happens to the average density of the marine vessel when these compartments are completely filled with water.
(c) State the exact relationship between the weight of the vessel and the weight of the displaced water when the vessel is rising up to the surface.

Ans :

(a) The rectangular compartments located inside the front and rear parts of the submarine are specifically known as ballast tanks or floatation tanks.
(b) When these tanks are filled entirely with water, the average density of the submarine significantly increases and becomes more than the density of the sea water.
(c) 1. When the submarine is rising to the surface, the compressed air forcefully empties the tanks, making the average density of the submarine less than the sea water.
2. As a direct result, the total weight of the water displaced by its partially submerged portion becomes equal to the total weight of the submarine.

127. Neha visits a seaport and observes a large cargo vessel floating on the seawater. She notes a specific reference mark painted on the side of the vessel's hull. The captain explains that this mark ensures the vessel is not loaded beyond a safe limit. Neha uses a diagram of this reference mark to understand how ships transition safely between waters of different densities without accidentally sinking.



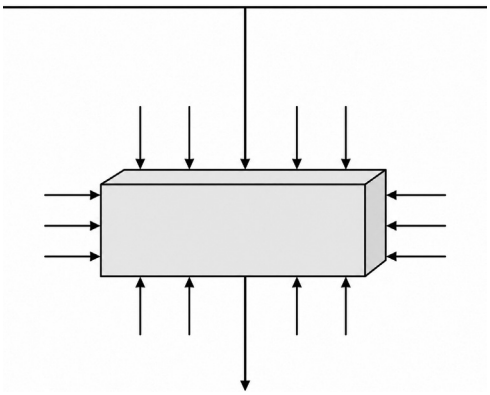
(a) Name the specific white line reference mark painted on the side of the marine vessel.
(b) State what happens to the vessel when it is loaded with cargo until this reference mark touches the water level.
(c) State what happens to the vertical position of the vessel when it sails from seawater into river water.
(d) Give one specific reason why an unloaded vessel is safely filled with sand or stones at its bottom.

NODIA

Ans :

(a) The specific white line reference mark painted on the exterior side of every ship is formally called the Plimsoll line.
(b) When the Plimsoll line touches the water level, the ship has reached its safe limit of loading and is absolutely not allowed to be loaded further.
(c) When a ship sails from denser seawater into less dense river water, it immediately begins to submerge further down to displace more volume of water.
(d) An unloaded ship is heavily filled with sand or stones at its bottom to carefully lower its centre of gravity, preventing it from tipping over during strong winds.

128. Vikram is analysing the forces acting on a metal cube of side 4 cm completely immersed in a liquid of density 1.1 g cm^{-3}. The top surface of the cube is at a certain depth, and the bottom surface is at a greater depth. He uses a diagram illustrating the vertical and horizontal forces acting on the different faces of the completely immersed cube to understand why an upward force is generated.



(a) Calculate the volume of the metal cube and state what happens to the horizontal forces acting on the vertical sides of the cube.
(b) Calculate the upward force acting on the cube due to the completely displaced liquid.

OBJECTIVE QUESTIONS

1. What does the internal energy of a body strictly comprise according to the kinetic molecular theory?
(A) Only the vibrational kinetic energy of molecules
(B) Only the potential energy due to intermolecular forces
(C) The sum of kinetic energy and potential energy of its molecules
(D) The sum of macroscopic kinetic energy and gravitational potential energy

Ans : (C)

Every substance consists of molecules in random motion that exert attractive forces on each other. The sum of the kinetic energy due to this motion and the potential energy due to intermolecular attraction perfectly constitutes the total internal energy of the body.

2. When air is pumped into a bicycle tube, the barrel of the pump becomes heated. Which specific energy conversion is primarily responsible for this effect?
(A) Electrical energy transforms into heat energy.
(B) Mechanical energy transforms into heat energy.
(C) Chemical energy transforms into heat energy.
(D) Potential energy transforms into electrical energy.

Ans : (B)

Pumping air into a bicycle tube requires physical effort, which is a form of doing work. During this process, the mechanical energy expended by the person is directly converted into heat energy, causing the barrel of the pump to become warm.

3. Which of the following relationships correctly represents the conversion between the SI unit and the CGS unit of heat energy?
(A) 1 joule = 10^5 erg
(B) 1 joule = 10^7 erg
(C) 1 erg = 10^7 joule
(D) 1 erg = 4.2 joule

Ans : (B)

The standard International System of Units measures heat energy in joules, while the Centimetre-Gram-Second system measures it in ergs. One joule of heat energy is mathematically equivalent to exactly ten raised to the power of seven ergs in the CGS system.

4. An analyst records observations on two physical phenomena, X and Y, related to the energy of molecules in a substance.

Property	**Phenomenon X**	**Phenomenon Y**
Definition	The sum of the kinetic and potential energies of all molecules in a body.	A measure of the average kinetic energy of the molecules in a body.
Nature	It is a form of energy.	It is a degree of hotness or coldness.
SI Unit	Joule (J)	Kelvin (K)

Based on the table, identify phenomena X and Y.
(A) X is Temperature; Y is Heat
(B) X is Internal Energy; Y is Temperature
(C) X is Heat; Y is Internal Energy
(D) X is Kinetic Energy; Y is Potential Energy

Ans : (B)

Phenomenon X is described as the total molecular energy (kinetic and potential), which defines internal energy. Heat is the transfer of this energy. Phenomenon Y is the measure of average molecular kinetic energy and determines the degree of hotness, which is the definition of temperature. The SI units provided further confirm this identification.

5. Consider the following statements regarding the physical characteristics of heat:
I. Heat is a material substance that occupies space.
II. Heat can be transformed into mechanical work.
III. Heat is a measurable quantity.
IV. Heat determines the direction of thermal energy flow.
Which of the statements given above are correct?
(A) I and IV
(B) II and III
(C) I, II, and III
(D) II, III, and IV

Ans : (B)

Heat is distinctly a form of energy and not a material substance, meaning it does not occupy physical space. While heat is a measurable quantity that can convert into mechanical work, the direction of thermal flow is exclusively determined by temperature.

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CHAPTER 6

Heat and Energy

SUMMARY

1. HEAT

Heat is a form of energy. Each object contains matter which is made up of molecules. These molecules are in a constant state of motion. This gives them kinetic energy. Also, there is a force of attraction between the molecules. This gives them potential energy.

1. Heat energy is the internal energy of these molecules. More the internal energy, hotter is the body.
2. Internal energy is the sum of kinetic energy due to motion of molecules and potential energy due to molecular attractive forces.
3. Heat is a form of energy which flows. It is the energy of random motion of molecules constituting the body.
4. The SI unit of heat is joule (J), and the CGS unit is erg.
5. Calorie and kilo calorie are also units of heat. 1 kilo calorie = 1000 cal Also, J and cal are related as 1 cal = 4.186 J

2. TEMPERATURE

The degree of hotness of a body is determined by a quantity known as temperature. Heat flows from a body at a higher temperature to a body at a lower temperature. If there is no transfer of heat between the two bodies in contact, then they are said to be at the same temperature. The SI unit of temperature is Kelvin (K). The other unit is degree Celsius ($^\circ C$). These two units are related as

$$\mathrm{T\,K} = t^\circ C + 273$$

There is another unit of temperature called degree Fahrenheit ($^\circ F$). $^\circ F$ and $^\circ C$ are related as

$$\mathrm{T}^\circ\mathrm{F} = \frac{9}{5} \times t^\circ\mathrm{C} + 32$$

The difference between Heat and temperature are as follows :

Heat	Temperature
It is a form of energy in motion	It is the measure of physical state, i.e., hotness or coldness of a substance.
Addition of heat changes the temperature of a substance.	It is the effect of addition of heat.
It is measured in joule (J) or calorie (cal).	It is measured in Celsius ($^\circ C$), Fahrenheit ($^\circ F$) or Kelvin (K).

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3. THERMAL EXPANSION

The expansion of a substance on heating is called the thermal expansion of that substance.

3.1 Type of Thermal Expansion

1. **Linear Expansion :** The increase in length of a substance on heating is called linear expansion.
2. **Superficial Expansion :** The increase in area of a substance on heating is called superficial expansion.
3. **Cubical Expansion :** The increase in volume of a substance on heating is called cubical expansion.

3.2 Anomalous Expansion of Water

Substances expand on heating and contract on cooling. However, water, silver iodide and silica are exceptions. These substances contract on heating and expand on cooling within a specific range of temperature. This is called anomalous expansion.

1. When water at $0^\circ C$ is heated, it is observed that it contracts in the range $0 - 4^\circ$C. Beyond 4°C, it expands normally. Similarly, when it is cooled from 4°C to 0°C, it expands.
2. The expansion of water when it is cooled from 4°C to $0^\circ C$ is known as anomalous expansion of water.

Ans :

(a) 1. Formula : Volume of cube
= Side × Side × Side -> Substitution: 4 cm × 4 cm × 4 cm -> Result: 64 cm^3

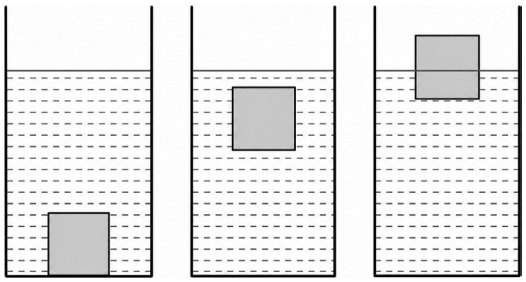
2. The horizontal thrust at various points on the vertical sides gets perfectly balanced because the liquid pressure is exactly equal at all points at the same depth.

(b) 1. Formula : Up-thrust
= Volume of submerged solid × Density of liquid × Acceleration due to gravity (g)

2. Substitution : Up-thrust
= 64 cm^3 × 1.1 g cm^{-3} × g

Result: Up-thrust = 70.4 gf

129. Sanjay conducts an experiment in the physics laboratory using three identical wooden blocks. He places them one by one into three separate glass containers filled with different liquids. He observes that the block in the first container sinks entirely, the block in the second container floats while completely immersed, and the block in the third container floats with a part of it safely remaining above the liquid surface.



(a) State the relationship between the weight of the block and the maximum upward force in the first container where the block sinks.

(b) State the value of the apparent weight of the block in the second container where it floats completely immersed.

(c) State the relationship between the density of the block and the density of the liquid in the third container.

(d) Identify which of the three liquids shown in the glass containers possesses the absolute highest density.

Ans :

(a) In the first container where the block sinks, the actual weight of the body is strictly greater than the maximum up-thrust exerted by the liquid.

(b) In the second container where the block floats while fully immersed, the apparent weight of the floating body is always exactly equal to zero.

(c) In the third container where the block floats partially immersed, the average density of the floating body is distinctly less than the density of the surrounding liquid.

(d) The liquid in the third container has the highest density, because it provides enough up-thrust to confidently float the block while only being partially submerged.

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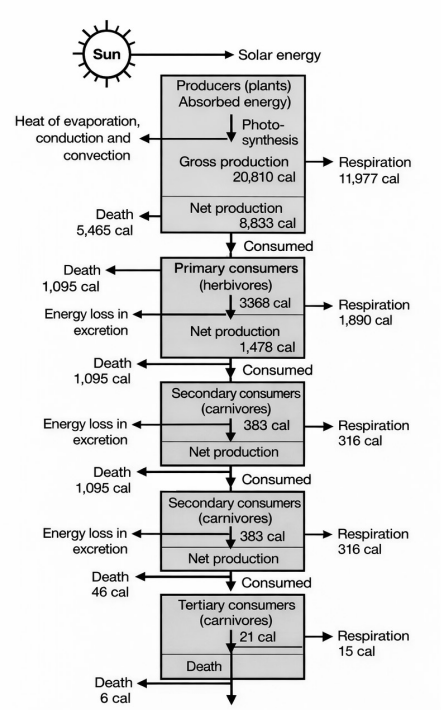
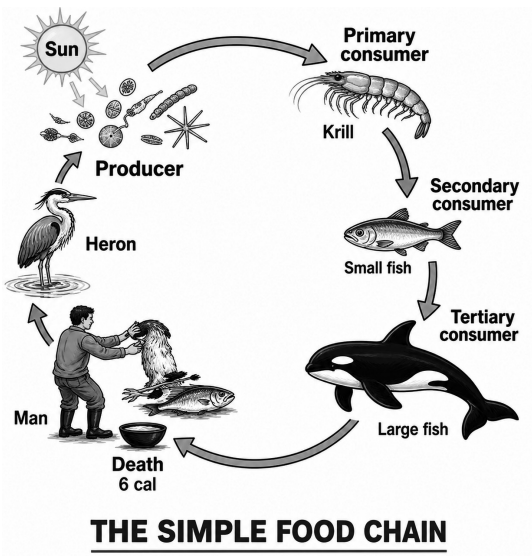


ENERGY FLOW IN ECOSYSTEM IN FORM OF A FOOD CHAIN

Application of Law of Thermodynamics

1. The entrance, transformation and diffusion of energy in the ecosystem are governed by the laws of thermodynamics.
2. First law of thermodynamics : Energy can neither be created nor be destroyed, but it can be transformed from one form to another.
3. Second law of thermodynamics : During the process of transformation of energy, a part of energy is converted in non-useful form such as heat.
4. Thus, the total sum of useful and non-useful energy remains constant.

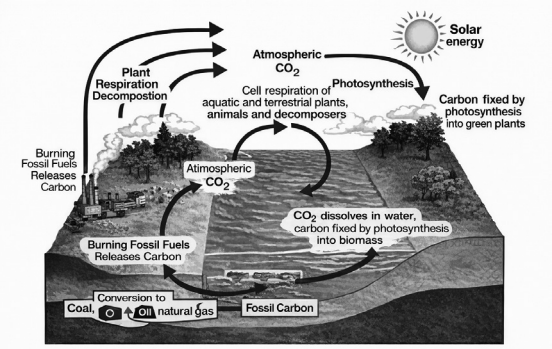


THE SIMPLE FOOD CHAIN

7. NUTRIENT FLOW

The regulation of biological activities and the formation of protoplasm in living organisms require various elements. These elements are called nutritive elements.

Just like energy does not vanish from the ecosystem, mineral elements also do not vanish. The carbon cycle is shown below.



THE SIMPLE FOOD CHAIN

8. RESOURCES

The matter which is useful for us is called a resource. Resources are essential for us to survive and flourish.

8.1 Classification of Resources

They are classified in two categories on the basis of utility and availability.

(i) **Renewable resources :** The resources which can be renewed along with their utilisation are called renewable resources. They are always available for use.

(ii) **Non-renewable resources :** The resources which cannot be practically renewed are called non- renewable resources. When they are depleted, they cannot be replaced easily over a long period of time.

The difference between renewable and non renewable sources are as follows :

Renewable	Non-renewable
They can be renewed and used continuously over a long period of time.	They cannot be
They are non-conventional resources.	They are conventional
They do not get exhausted.	They can get exhausted if used indiscriminately.
Examples : Air, water, plants.	Examples : Minerals, coal, fuel.

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9. CONSERVATION OF RESOURCES

The management of natural resources for all living beings by which the needs of not only the present generation but also all the possibilities remain for nurturing them for future generations is known as conservation of resources.

9.1 Natural Resources and Their Conservation Water

About 75% of the Earth is submerged under water, but all this water is not useful for us. Of the 75%, 97% is present in oceans and is not useful as it is salty. About 2% of water is present in the form of snow. Thus, only 1% of water is consumable by us.

Water is a rare resource and its conservation is a must.

9.2 Conservation

To conserve water, we need to take the following steps:

1. Check dams, tanks and ponds must be built for harvesting rain water.
2. The hillsides must be terraced to reduce the downward flow of rain water.
3. Field bunds and ponds must be created.
4. Contour trenches must be built to collect run-off water.

9.3 Forest

The terrestrial area densely covered by trees and shrubs is called forest. Forests and wildlife are essential to maintain the ecological balance.

Deforestation causes destruction of plants, animals and micro-organisms and increases the greenhouse effect and global warming. Therefore, forest conservation is essential.

9.4 Conservation

To conserve forest, we need to take the following steps:

(i) Cutting of trees must be banned.
(ii) Deforestation must not be allowed.

9.5 Soil

1. Soil is a basic natural resource. The surface of ground is called soil.
2. It is the mixture of different mineral salts and is formed by the disintegration and decomposition of rocks and mountains, and by a combination of the organic substance humus.
3. It is essential to conserve soil so as to maintain the production of the three basic needs of human beings food, fibre and fuel.

9.6 Conservation

To conserve soil, we need to take the following steps:

1. Erosion of soil by wind, water etc. reduces its fertility. Hence, this must be prevented.
2. The use of land should be managed such that it can provide protection from soil deterioration caused by natural or human stimulating factors.

9.7 Minerals

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1. The core of the Earth is composed of different types of rocks which contain a mixture of various minerals.
2. The minerals are available in limited quantities. They are non-renewable resources, and hence, their conservation is necessary.
3. Conservation of minerals does not mean to stop using them. They should be consumed in a way such that it causes lesser load on mining so reserves last long.

9.8 Conservation

To conserve minerals, we need to take the following steps:

1. Objects should be reused again and again.
2. Minerals which are abundant in large quantities should be used in place of less available minerals.
3. Discarded objects must be recycled to obtain new products.

9.9 Energy

1. The major sources of energy are wood, fossil fuels (e.g., coal, petroleum and natural gas) and radioactive substances (e.g., uranium).
2. These energy sources are non-renewable, so they will ultimately get exhausted.
3. Air pollution, acid rain and global warming are caused by the combustion of fossil fuels and production of nuclear energy.
4. Therefore, it has become essential to reduce the use of fossil fuels and nuclear energy, and to substitute them by the renewable resources of energy.

9.10 Oceans and marine life

1. Oceans cover nearly 70% of the Earth's crust.
2. These oceans are the resources of algae, animals, sea plants and minerals required for human welfare.
3. Thus, their conservation is as essential as any other resource.

10. ENERGY ALTERNATIVES AND PROMOTION OF RENEWABLE ENERGY RESOURCES

Solar Energy

1. The Sun is an inexhaustible and pollution-free source of radiation energy. It has been radiating energy for the past 5 billion years and will continue to do so for the next 5 billion years or so.
2. A solar cooker is a heating device which is used to cook food by using the energy radiated by the Sun.
3. A solar heater is used to heat water by using the energy radiated by the Sun. Solar power plants are used to produce electricity by using solar energy.
4. Solar cells are used to convert solar energy directly into electrical energy.
5. Solar energy is indirectly used to obtain biomass fuel which is obtained from substances synthesised by photosynthesis.

Hydro power or Hydro - Electric Energy

6. Water at a height has potential energy stored in it. When this water falls down, its potential energy is converted to kinetic energy.
7. Hydro-power plants use this kinetic energy to generate electricity.
8. The water from the high level in the dam is carried through pipes to the turbine at the bottom of the dam. The turbine of the generator rotates, and the generator produces electricity.

Wind Energy

9. Air in motion is called wind.
10. It possesses kinetic energy. Thus, it can be used to produce electricity.
11. Windmills are used to generate electricity from wind energy.
12. Wind energy is an inexhaustible source of energy.
13. A windmill is a simple machine with a structure similar to a large fan erected at some height. The rotatory motion of the windmill is used to run the turbine of the electric generator.
14. Wind speed of about 25 km/h is needed to run a wind mill.

Tidal Energy

15. Due to the gravitational pull of the Moon on the spinning Earth, the level of water in the sea rises and falls. This phenomenon is called high and low tides, and the difference in sea levels gives us tidal energy.
16. Tidal energy is harnessed by constructing a dam across a narrow opening to the sea.
17. A turbine fixed at the opening of the dam converts tidal energy to electricity.

Geo-Thermal Energy

18. Due to geological changes, molten rocks formed in the deeper hot regions of Earth's crust are pushed upwards and are trapped in certain regions called hot spots.
19. When underground water comes in contact with the hot spot, steam is generated. Sometimes, hot water from that region finds outlets at the surface. Such outlets are known as hot springs.
20. The steam trapped in rocks is routed through a pipe to a turbine of a generator which generates electricity.

Disadvantages of Building Large Dams

21. Construction of large dams for generating hydro-electric power has the following disadvantages:
    (i) Disruption of plant and animal life
    (ii) Large-scale displacement of people
    (iii) Disturbance of the natural ecosystem
    (iv) Disruption of the aquatic ecosystem

Efficient Use of Energy

22. The use of compact fluorescent light (CFL) saves up to 67% energy. CFL also lasts $6 - 10$ times longer than regular incandescent bulbs.
23. Insulation allows a building to use less energy in heating and cooling in order to achieve and maintain a comfortable temperature.
24. Modern energy-efficient appliances such as refrigerators, air conditioners, ovens and dryers use less energy than their older counterparts.
25. Fuel efficiency of vehicles can be increased by reducing the weight of the vehicle and using advanced tyres and computer-controlled engines.
26. A building's location and its surroundings play a key role in regulating its temperature and illumination. Proper placement of windows and the use of features which reflect light into a building can reduce the need of artificial light.

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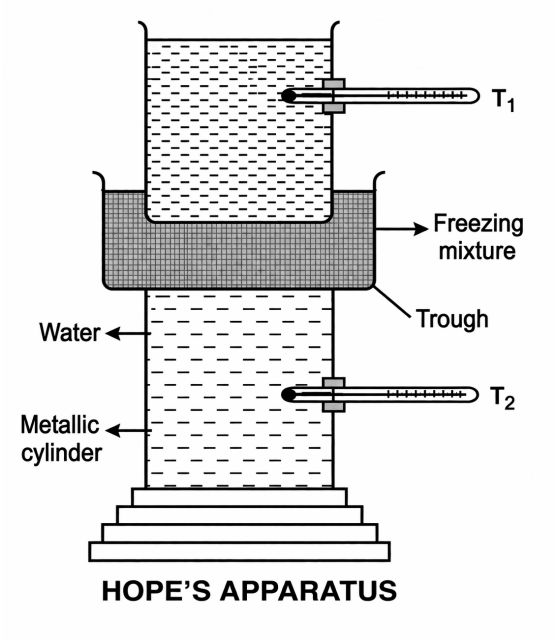
4. HOPE'S EXPERIMENT

The Hope's apparatus is used to demonstrate anomalous expansion of water. It was devised by T. C. Hope in 1805.



HOPE'S APPARATUS

Consequences of Anomalous Expansion of Water

1. Preserving of aquatic life in very cold weather
2. Bursting of water pipes, plant capillaries and rocks

5. TEMPERATURE SCALES

Temperature is measured by using an instrument called a thermometer. In laboratories, a mercury thermometer is used which is based on volume expansion of mercury with temperature.

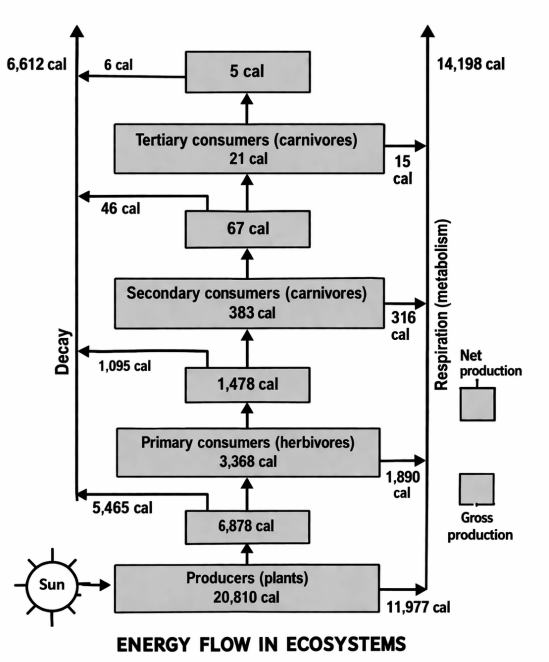
The temperature is expressed in three scales:

1. **Celsius scale :** This scale was introduced by Celsius, a Swedish astronomer.
   (i) On this scale, the lower fixed point, i.e., the ice point is marked as $0°C$.
   (ii) The upper fixed point, i.e., the steam point, is marked as $100°C$.
   (iii) The interval between these two points is marked by 100 equal parts. Each part is called one degree Celsius ($°C$).
   (iv) A degree on the Celsius scale is 1/100th part of the interval between the ice point and the steam point.
2. **Fahrenheit scale :** This scale was introduced by Fahrenheit, a Russian physicist.
   (i) On this scale, the lower fixed point, i.e., the ice point, is marked as 32°F.
   (ii) The upper fixed point, i.e., the steam point, is marked as 212°F.
   (iii) The interval between these two points is marked by 180 equal parts. Each part is called one degree Fahrenheit (°F).
   (iv) A degree on the Fahrenheit scale is 1/180th part of the interval between the ice point and the steam point.

6. ENERGY FLOW AND CONSERVATION OF RESOURCES

6.1 Energy Flow and Its Importance

Energy is needed for all biological activities. The most important source of energy for all ecosystems on the Earth is the Sun. Plants absorb most of the light falling on them in the form of energy. Of this absorbed energy, only 0.02% is used in photosynthesis. The energy flow in the ecosystem is shown below.



ENERGY FLOW IN ECOSYSTEMS

The energy flow in the ecosystem can also be understood as a food chain. It is shown below.

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6. The zero of the Kelvin scale is known as absolute zero. What physical phenomenon theoretically occurs at this specific temperature?
(A) Water reaches its maximum possible density.
(B) The volume of a gas becomes infinite.
(C) All random molecular motion completely ceases.
(D) The substance transforms directly into a plasma.

Ans : (C)

Absolute zero is defined as the theoretical temperature at which a substance possesses minimal thermal energy. At exactly zero Kelvin or negative two hundred seventy-three degrees Celsius, the kinetic energy of particles drops to zero, and all random molecular motion completely ceases.

7. There are exactly 100 equal degrees between the ice point and the steam point on the Celsius scale, while the Fahrenheit scale has 180 divisions. Based on this, one degree on the Celsius scale corresponds to how many degrees on the Fahrenheit scale?
(A) 5/9 degree
(B) 9/5 degree
(C) 273 degree
(D) 32 degree

Ans : (B)

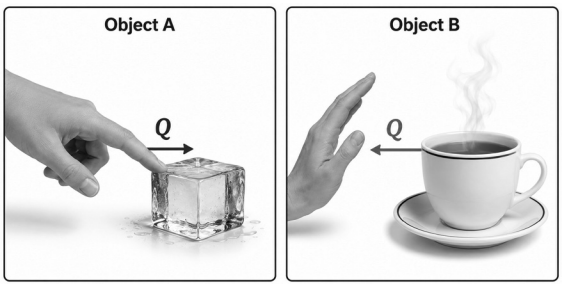
The Celsius scale defines the fundamental interval between the freezing and boiling points of water using one hundred equal divisions. The corresponding interval on the Fahrenheit scale contains one hundred eighty divisions, making one Celsius degree equivalent to nine-fifths Fahrenheit degrees.

8. **Assertion (A) :** The physical state and dimensions of a body may change when it receives heat energy.
Reason (R) : The flow of heat always occurs from a body possessing greater internal energy to a body possessing lesser internal energy.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The dimensions or state of a substance often alter upon heating due to increased molecular vibration. However, heat flows strictly based on temperature differences rather than the total internal energy, meaning the provided reason contains a fundamentally incorrect scientific premise.

9. The diagram illustrates the sensation felt when a hand comes into contact with two different objects. Which statement correctly explains the direction of heat energy transfer?



(A) In both cases, 'coldness' flows from the object to the hand.
(B) In both cases, heat energy (Q) flows from the hand to the object.
(C) Heat energy (Q) flows from the hand to object A, and from object B to the hand.
(D) Heat energy (Q) flows from object A to the hand, and from the hand to object B.

Ans : (C)

Explanation: Heat is a form of energy that always flows from a region of higher temperature to a region of lower temperature. The hand is warmer than the ice cube (Object A), so heat flows from hand to ice. The hot tea (Object B) is warmer than the hand, so heat flows from the cup to the hand.

10. Match the physical quantities in List-I with their corresponding defining characteristics in List-II.
List-I
P. Heat
Q. Temperature
R. Joule
S. Kelvin
List-II
I. Determines the direction of thermal flow
II. Represents the sum of internal energies
III. The SI unit of thermal state measurement
IV. The SI unit of transferred thermal energy
(A) P-I, Q-II, R-III, S-IV
(B) P-II, Q-I, R-IV, S-III
(C) P-II, Q-I, R-III, S-IV
(D) P-I, Q-II, R-IV, S-III

Ans : (B)

Heat represents the total internal energy transferred, measured in joules. Temperature

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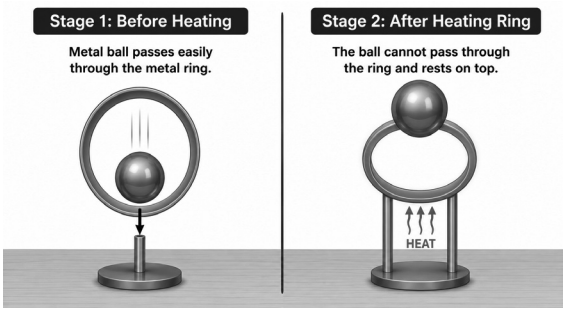
29. In cold hill stations, water supply pipes often burst when the environmental temperature unexpectedly drops below freezing point. What is the fundamental physical reason behind this destructive phenomenon?

(A) The metallic pipes contract drastically, crushing the water confined inside them.
(B) Water freezes into ice and significantly expands in volume, exerting immense outward pressure.
(C) The atmospheric pressure drops suddenly, causing the liquid water to aggressively boil and rupture the pipes.
(D) The rapid cooling causes a complete vacuum to form, making the structural pipes intuitively implode.

Ans : (B)

When temperatures fall aggressively below zero degrees Celsius, the flowing water crystallizes into solid ice. Due to the anomalous behaviour of water, this phase transition involves a substantial increase in physical volume, which consequently exerts overwhelming mechanical pressure on the pipe walls.

30. The diagram shows a common experiment involving thermal expansion. What will be observed when the metal ring is uniformly heated and an attempt is made to pass the ball through it again?


Stage 1: Before Heating
Metal ball passes easily through the metal ring.
Stage 2: After Heating Ring
The ball cannot pass through the ring and rests on top.
HEAT

(A) The ball will pass through as the hole in the ring contracts.
(B) The ball will not pass through as the hole in the ring has expanded.
(C) The ball will pass through more easily as the hole in the ring has expanded.
(D) The ball will not pass through as the metal of the ring has become less dense.

Ans : (C)

When a substance is heated, it expands in all directions. This phenomenon is called thermal expansion. Heating the ring causes the metal to expand, which makes the circumference of the ring, and therefore its internal diameter (the hole), larger. Consequently, the ball, which passed through before, will now pass through more easily.

31. Similar to the bursting of supply pipes, crops can be completely destroyed during severely cold weather. How does the anomalous thermal expansion of water trigger this biological destruction?

(A) The soil rapidly absorbs all the available water, leaving the delicate plants completely dehydrated.
(B) Water inside the plant capillaries completely evaporates due to rapid sublimation, causing the stems to wither.
(C) Water freezing inside the plant capillaries expands in volume, bursting the delicate cell walls and killing the plant.
(D) The plant roots fundamentally shrink due to cold, cutting off all underground nutritional pathways.

Ans : (C)

Plants consistently transport necessary water from their root systems upward through microscopic internal capillaries. When freezing environmental temperatures occur, this internal liquid expands as it turns into solid ice, exerting severe hydrostatic pressure that structurally ruptures the vital capillary walls.

32. Identify the pair that correctly correlates a specific physical quantity or unit with its accurate corresponding numerical conversion value based on the CGS and SI systems.

(A) 1 Kilo-calorie : 4,200 Joules
(B) 1 Joule : 4.186 Calories
(C) 1 Calorie : 1,000 Joules
(D) 1 Erg : 10^7 Joules

Ans : (A)

Heat energy is commonly quantified using distinct standard units depending on the preferred measurement system. The conversion explicitly states that one single calorie approximately equals four point two joules, thereby meaning one kilo-calorie definitively equates to four thousand two hundred joules.

33. Consider the following statements regarding the variation of water's density with changing temperature:

I. The maximum possible density of pure water is precisely 1.000 g cm^{-3} at 4°C.
II. Heating water strictly above 4°C

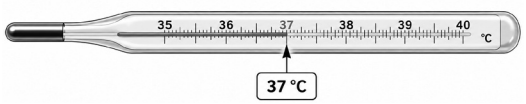
NODIA

(C) Silica exhibits expansion upon cooling at temperatures below negative eighty degrees Celsius.
(D) Anomalous expansion refers to the unusual property of expanding during cooling over a certain range.

Ans : (B)

Silver iodide exhibits anomalous behaviour by actually expanding when cooled from one hundred forty-one degrees down to eighty degrees Celsius. Stating that it contracts upon cooling within this precise temperature interval directly contradicts its uniquely documented anomalous thermal expansion characteristics.

16. The diagram shows a clinical thermometer. If this thermometer reading of 37 °C were measured using a scientific thermometer calibrated in the SI unit of temperature, what would the reading be?



(A) 236 K
(B) 273 K
(C) 310 K
(D) 37 K

Ans : (C)

The SI unit of temperature is Kelvin (K). The relationship between the Celsius scale (t°C) and the Kelvin scale (T K) is given by the formula T (K) = t (°C) + 273. Therefore, a temperature of 37 °C is equivalent to 37 + 273 = 310 K. This conversion is essential for scientific calculations.

17. A graph is plotted showing the variation in the volume of 1 gram of water as its temperature increases from 0°C to 10°C. Which of the following best describes the shape of the resulting curve?
(A) A strictly linear upward slope.
(B) A strictly linear downward slope.
(C) A U-shaped curve with its minimum exactly at 4°C.
(D) A bell-shaped curve with its maximum exactly at 4°C.

Ans : (C)

When water is heated from absolute freezing at zero degrees Celsius, it unusually contracts until reaching four degrees Celsius, making its volume minimal at this point. Further heating causes normal expansion, yielding a characteristic U-shaped graphical curve for volumetric variation.

18. **Assertion (A) :** The density of water steadily increases when it is heated from 0°C to 4°C.
Reason (R) : Heating water from 0°C to 4°C causes its volume to decrease while its mass remains entirely constant.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Density is mathematically defined as mass divided by volume. Since the anomalous contraction of water between zero and four degrees Celsius reduces its volume without altering its mass, the resulting density must logically increase, reaching its maximum possible value simultaneously.

19. Consider a sample of pure water being cooled steadily from 10°C down to 0°C. Which of the following sequences correctly describes the change in its density during this cooling process?
(A) Steadily increases, reaches a maximum at 4°C, then steadily decreases.
(B) Steadily decreases, reaches a minimum at 4°C, then steadily increases.
(C) Remains perfectly constant until 4°C, then sharply decreases.
(D) Steadily increases throughout the entire temperature drop.

Ans : (A)

As water cools from ten degrees down to four degrees Celsius, it undergoes normal thermal contraction, causing its density to increase. Below four degrees Celsius, anomalous expansion begins, making the volume increase and resulting in a steady decrease in overall density.

20. A uniform metal sheet containing a circular hole in its exact centre is subjected to uniform heating. What will happen to the physical dimensions of the central hole during this process?
(A) The hole will decrease in size due to inward expansion.
(B) The hole will increase in size symmetrically.
(C) The hole will gradually become distinctly elliptical.
(D) The size of the hole will remain completely unaffected.

Ans : (B)

Thermal expansion fundamentally increases the mean separation between all constituent molecules

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indicates the specific thermal state deciding flow direction, measured in kelvins. Matching these attributes directly links the fundamental thermodynamic causes and effects to their respective international standard units correctly.

11. **Assertion (A) :** Two bodies possessing the exact same quantity of heat may still experience a transfer of thermal energy when placed in physical contact.
Reason (R) : Thermal energy strictly flows from a body at a higher temperature to a body at a lower temperature until their temperatures equalize.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Two bodies can contain identical amounts of heat while existing at entirely different temperatures due to differing mass or material properties. Because temperature fundamentally drives the direction of thermal transfer, energy will still flow until absolute thermal equilibrium is firmly established.

12. When a solid substance is heated, it undergoes thermal expansion. What is the fundamental microscopic cause of this physical expansion?
(A) The individual molecules increase in their physical size and mass.
(B) The intermolecular forces completely vanish, allowing free movement.
(C) The increased kinetic energy pushes neighbouring molecules further apart.
(D) The substance absorbs surrounding gas molecules into its structure.

Ans : (C)

Heating provides thermal energy that significantly increases the average kinetic energy of the constituent molecules. This resulting rapid vibration forces neighbouring molecules apart, thereby increasing the mean intermolecular separation and visibly manifesting as an overall dimensional expansion of the heated substance.

13. Consider the following statements about thermal expansion in different states of matter:
I. Liquids and gases do not possess a definite shape and exhibit only cubical expansion.
II. Superficial expansion refers exclusively to the increase in the volume of an object.
III. Gases expand significantly more than liquids when subjected to the same temperature rise.
IV. Solids exhibit linear, superficial, and cubical expansion simultaneously.
Which of the statements provided above are correct?
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I and IV only

Ans : (B)

Superficial expansion specifically denotes an increase in the surface area of a solid, whereas cubical expansion refers to volumetric changes. Since fluids lack a definitive fixed shape, they solely undergo cubical expansion, with gases displaying much greater expansivity than surrounding liquids.

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14. An experiment investigates the factors affecting the internal energy of three copper blocks.

Block	Mass (kg)	Temperature (°C)	Material
A	2	40	Copper
B	1	80	Copper
C	2	40	Copper
D	2	60	Copper

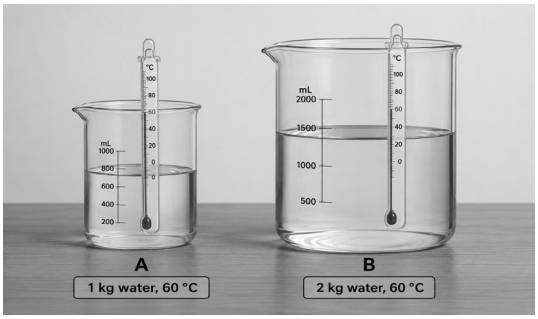
Which block possesses the greatest amount of internal energy?
(A) Block A
(B) Block B
(C) Block C
(D) Block D

Ans : (D)

The total internal energy of a body depends on its mass, temperature, and material. Comparing blocks A, C, and D, which have the same mass (2 kg) and material (Copper), Block D has the highest temperature (60°C). Block B has a higher temperature but half the mass. Therefore, Block D possesses the greatest internal energy.

15. Which of the following statements regarding the anomalous expansion of certain materials is mathematically or conceptually incorrect?
(A) Water expands upon cooling from four degrees Celsius down to zero degrees Celsius.
(B) Silver iodide contracts upon cooling within the temperature range of 80 degrees Celsius to 141 degrees Celsius.

25. Two beakers, A and B, contain pure water at the same temperature as shown. Which statement correctly compares the heat energy contained in them?



(A) Beaker A and Beaker B contain the same amount of heat energy.
(B) Beaker A contains more heat energy than Beaker B.
(C) Beaker B contains more heat energy than Beaker A.
(D) The heat energy cannot be compared without knowing the room temperature.

Ans : (C)

Heat energy, or internal energy, is the sum of the kinetic and potential energies of all molecules in a substance. Although both beakers are at the same temperature (same average molecular kinetic energy), Beaker B has double the mass of water. Therefore, it contains twice as many molecules and thus has a greater total internal energy.

26. Match the observation phases in List-I with the corresponding temperature readings in List-II during Hope's experiment.
List-I
P. Lower thermometer final steady reading
Q. Upper thermometer final steady reading
R. Temperature at which water achieves maximum density
S. Initial temperature of the water in the cylinder
List-II
I. 0°C
II. 4°C
III. Room temperature (e.g., 16°C)
IV. 4°C
(A) P-II, Q-I, R-IV, S-III
(B) P-I, Q-II, R-IV, S-III
(C) P-IV, Q-III, R-I, S-II
(D) P-II, Q-IV, R-I, S-III

Ans : (A)

The lower thermometer reaches and holds a final steady temperature of four degrees Celsius where water attains its maximum density. The upper thermometer steadily drops until it reads zero degrees Celsius as the lighter, colder water expands and rises upward.

27. **Assertion (A) :** During severe winter, an open lake always begins freezing from the topmost surface rather than the bottom.
Reason (R) : Water at 0°C is significantly less dense than water at 4°C, causing it to float over the warmer bottom layers.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

As atmospheric temperatures drop, the surface water cools to four degrees Celsius and sinks. Further cooling below four degrees Celsius causes the water to expand anomalously, decreasing its density. This lighter, colder water remains floating on top, eventually freezing into ice.

28. Aquatic animals can survive in extreme cold weather even when the surface of a pond freezes completely. What intrinsic physical property of ice aids in preserving the comparatively warmer liquid environment below?
(A) Ice acts as an excellent thermal conductor, constantly drawing internal heat from the earth below.
(B) Ice is fundamentally a poor conductor of heat, effectively insulating the deeper water from the freezing atmosphere.
(C) Ice dissolves large quantities of oxygen, generating sufficient metabolic heat for immediate aquatic survival.
(D) Ice possesses an extremely high specific heat capacity, absorbing atmospheric coldness efficiently.

Ans : (B)

The solid ice layer that forms over the surface functions as a highly effective thermal insulator. Because ice conducts heat very poorly, it robustly prevents the retained thermal energy in the deeper, warmer water layers from escaping into the freezing atmosphere.

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immediately adjacent neighbouring internal molecules noticeably further apart.
(C) The surrounding atmospheric gases aggressively penetrate the internal solid structure during active heating.
(D) The intrinsic chemical composition completely breaks down rapidly, releasing numerous large expansive gas bubbles.

Ans : (B)

Supplying substantial heat significantly increases the localized internal average kinetic energy. Consequently, the rapid localized microscopic vibrations essentially overcome normal attractive forces, actively pushing adjacent molecular structures steadily apart and directly causing the distinct visible macroscopic manifestation known scientifically as thermal expansion.

47. Identify the incorrectly matched pair concerning the specific varying types of thermal structural expansion observed across different distinct states of physical matter.
(A) Gaseous bodies : Exclusively display cubical physical expansion
(B) Solid bodies : Display linear, superficial, and cubical physical expansion
(C) Liquid bodies : Exclusively display distinct superficial physical expansion
(D) Heated metals : Display distinct linear physical expansion along one specified dimension

Ans : (C)

Superficial expansion relates strictly to an increase in distinct two-dimensional physical surface area, a specific structural property utterly lacking in fluid mechanics. Liquids explicitly do not possess a definitively fixed stable structural shape, completely restricting their thermal variations exclusively to bulk volumetric expansion.

48. A standard glass bottle completely filled with pure water and securely sealed tight is placed deep inside a sub-zero freezer. What is the most highly probable physical outcome of this specific action?
(A) The glass structural walls will immediately melt due to a sudden internal localized pressure drop.
(B) The confined liquid water will permanently remain a stable supercooled liquid indefinitely.
(C) The contained water will significantly expand upon freezing structurally, ultimately shattering the rigid glass entirely.
(D) The solid glass itself will aggressively expand inward steadily, forcefully squeezing the fluid outward.

Ans : (C)

When chilled precisely below four degrees Celsius, liquid water anomalously undergoes distinct structural expansion rather than standard physical contraction. Once firmly transitioning into solid ice, its absolute internal physical volume expands drastically, exerting overwhelming hydrostatic outward pressure sufficient to violently fracture solid glass.

49. In strictly cold mountainous regions, maintaining external structural water pipelines poses severe logistical challenges during harsh deep winter months. What specific fundamental property strictly causes the structural failure of these pipelines?
(A) The rapid superficial metallic structural expansion actively triggered by severely chilling external winds.
(B) The unique intrinsic volumetric increase experienced heavily by liquid water when actively transitioning to solid ice.
(C) The dramatic metallic linear contraction systematically compressing internal liquid water into dense structural micro-crystals.
(D) The gradual internal accumulation of microscopic dissolved internal structural air bubbles actively weakening the metallic joints.

Ans : (B)

During significantly extreme plunging winter temperatures, the circulating internal liquid eventually freezes completely. Because water uniquely exhibits an anomalous distinct volumetric expansion structurally upon freezing, it generates an immense unavoidable internal physical pressure that easily exceeds the ultimate tensile strength of steel pipes

50. Which of the following components occupy the first trophic level in a given food chain?
(A) Fungi and bacteria
(B) Primary consumers and herbivores
(C) Green plants and photosynthetic bacteria
(D) Secondary consumers and carnivores

Ans : (C)

In any given ecosystem, green plants and photosynthetic bacteria synthesize their own food by using solar energy. They form the base of all food chains. These organisms are classified as producers and they occupy the very first trophic level of nourishment.

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systematically causes an overall increase in its density.

III. Cooling pure water from 4°C down to 0°C uniformly causes a reduction in its density.

IV. The volumetric mass of water remains mathematically constant irrespective of extreme temperature changes.

Which of the statements provided above are scientifically correct?

(A) I and II only
(B) I and III only
(C) II and IV only
(D) I, III, and IV

Ans : (B)

Water exhibits its absolute maximum density at exactly four degrees Celsius. Heating it beyond this specific point or cooling it below this exact temperature will consistently cause structural expansion, leading directly to a continuous and measurable overall decrease in substance density.

34. The following table provides data on the volume of 1 gram of pure water at different temperatures. This data corresponds to the graph in Fig. 6.2 of the chapter.

Temperature (°C)	Volume of 1 g of water (cm^3)
0	1.00013
2	1.00003
4	1.00000
6	1.00003
8	1.00017
10	1.00030

Based on the data, what conclusion can be drawn about the volume of water?

(A) The volume of water is minimum at 0°C.
(B) The volume of water continuously increases with temperature.
(C) The volume of water is minimum at 4°C.
(D) The volume of water continuously decreases with temperature.

Ans : (C)

The table clearly shows that as water is heated from 0°C, its volume decreases, reaching a minimum value of 1.00000 cm^3 at 4°C. On further heating beyond 4°C, the volume begins to increase again. This unique behaviour is known as the anomalous expansion of water, making its volume minimum at 4°C.

35. **Assertion (A) :** Heat cannot be classified or treated mathematically as a physical material substance.

Reason (R) : Heat can be readily transformed into mechanical work, which itself is completely devoid of physical mass.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Earlier historical theories wrongly categorized heat as a tangible fluid material. Modern physics demonstrates that heat is simply transferable energy capable of doing intangible mechanical work, proving definitively that it entirely lacks mass and cannot be considered a standard material substance.

36. Heat energy is frequently measured in calories within specific scientific contexts. To what precisely is the measurement unit calorie fundamentally related?

(A) The absolute thermal capacity of metallic conductors.
(B) The precise SI measurement standard for mechanical work.
(C) The classical CGS unit quantifying internal kinetic energy.
(D) The historical non-SI unit specifically established for heat measurement.

Ans : (D)

While the standard SI measurement for all forms of energy is fundamentally the joule, the calorie remains a widely utilized non-SI metric unit. It was historically established specifically to quantify and mathematically represent the transfer of heat energy in classical thermodynamic systems.

37. When analysing the time-temperature graph generated during Hope's experiment, which of the following accurately describes the final steady state of the system?

(A) The upper thermometer reading stabilizes exactly at 4°C while the lower reading stabilizes at 0°C.
(B) Both the upper and lower thermometers systematically stabilize exactly at the uniform room temperature.
(C) The upper thermometer reading stabilizes exactly at 0°C while the lower reading stabilizes at 4°C.

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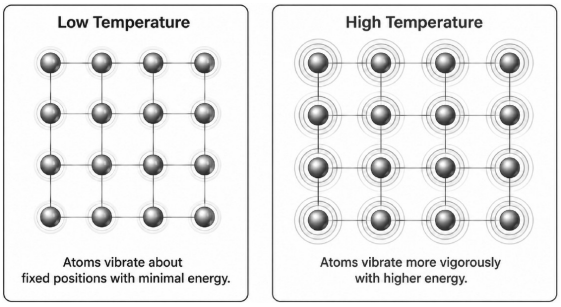
(D) Both distinct thermometers ultimately reach and steadily maintain absolute zero simultaneously.

Ans : (C)

Due to the unique anomalous expansion characteristic of water, the densest liquid structurally settles at the base. Consequently, the lower thermometer permanently stabilizes at exactly four degrees Celsius, while the lighter, colder water rises, freezing the upper thermometer reading at zero.

38. The diagram illustrates the molecular arrangement of a solid at two different temperatures. Which statement correctly explains the phenomenon of thermal expansion based on this model?


Low Temperature
Atoms vibrate about fixed positions with minimal energy.
High Temperature
Atoms vibrate more vigorously with higher energy.

(A) Heating causes molecules to decrease in size, creating more space.
(B) Heating increases the average kinetic energy and vibration of molecules, increasing their mean separation.
(C) Heating adds more molecules to the substance, causing it to expand.
(D) Heating weakens the attractive forces, causing the molecules to contract closer together.

Ans : (B)

When a substance is heated, its molecules absorb energy and their average kinetic energy increases. This results in more vigorous vibrations. The increased amplitude of vibration pushes the neighboring molecules further apart, leading to an increase in the average intermolecular distance. This macroscopic effect is observed as thermal expansion in length, area, and volume.

39. Heat transfer generally causes various immediate physical changes in a given substance. Which of the following is NOT an inherent consequence of supplying heat to a macroscopic body?
(A) The average internal kinetic energy of its constituent molecules increases.
(B) The mean physical separation between its neighbouring molecules widens.
(C) The intrinsic total mass of the substance increases proportionally.
(D) The overall volume of the given substance generally expands.

Ans : (C)

Providing thermal energy to an object directly stimulates molecular vibration, typically causing proportional structural expansion and corresponding changes in measurable physical density. However, this transferred thermal energy does not fundamentally generate new matter, meaning the absolute total mass remains entirely unaffected.

40. Consider the following statements comparing the general thermal expansion characteristics across different states of matter:
I. Gaseous substances demonstrate significantly more volumetric expansion than corresponding liquid substances.
II. Solid substances exclusively exhibit cubical expansion without any accompanying linear expansion.
III. A distinct decrease in overall density is widely noticeable when gases are heated uniformly.
IV. Liquid substances demonstrate both distinct linear and distinct superficial expansions simultaneously.
Which of the statements provided above accurately reflect established thermal principles?
(A) I and III only
(B) II and IV only
(C) I, II, and III
(D) III and IV only

Ans : (A)

Liquids and gases entirely lack defined shapes, precluding linear or superficial expansion in favour of solely cubical expansion. When uniformly heated, their fixed mass uniformly occupies a drastically greater volume, which consequently produces a noticeable corresponding decrease in their measurable density.

41. Two metallic blocks, X and Y, possessing vastly different masses but maintaining the exact same temperature, are placed in direct physical contact. What will happen regarding the transfer of heat between these two identical-temperature blocks?
(A) Heat will immediately flow from the block with greater mass to the block with lesser mass.
(B) Heat will immediately flow from the block with lesser mass to the block with greater mass.

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(C) No net transfer of heat energy will occur between the two distinct metallic blocks.
(D) Heat will flow back and forth continuously without ever establishing stable equilibrium.

Ans : (C)

The fundamental direction of thermal energy flow is governed exclusively by distinct differences in relative temperature, completely independent of total mass or internal energy content. Because both blocks maintain identical initial temperatures, absolute thermal equilibrium already exists, preventing any net heat transfer.

42. How is temperature fundamentally defined in relation to the general transfer of heat energy between two interactive systems?
(A) It strictly quantifies the total combined internal energy contained within both given interacting bodies.
(B) It acts as the specific physical effect that exclusively limits the maximum possible structural expansion.
(C) It provides the thermal state condition that fundamentally dictates the absolute direction of subsequent heat flow.
(D) It actively measures the exact amount of mechanical work generated during internal energy conversion.

Ans : (C)

Temperature functions uniquely as an indicator of an object's relative thermal state, defining its distinct degree of hotness or coldness. When separate bodies make contact, this relative state strictly determines the specific physical direction in which the internal thermal energy flows.

43. The SI unit of temperature is the Kelvin. According to strict scientific conventions, how is a specific temperature reading correctly denoted on this absolute scale?
(A) 273°K
(B) 273 K
(C) 273°C K
(D) 273 absolute degrees

Ans : (B)

While the Celsius and Fahrenheit measurement systems utilize the conventional degree symbol strictly in their notation, the modern Kelvin scale actively omits it. *A* recorded absolute thermodynamic measurement is formally written simply as a numerical value immediately followed by the capitalized letter *K*.

44. In the precise context of Hope's experiment, by which specific dominant mechanism of heat transfer does the water situated in the lower section of the cylinder primarily cool down?
(A) Rapid electromagnetic thermal radiation exclusively
(B) Direct microscopic thermal conduction evenly
(C) Downward displacement through internal thermal convection
(D) Mechanical agitation caused by internal molecular friction

Ans : (C)

As the centrally positioned cooling mixture chills the immediate adjacent water, the fluid undergoes normal contraction, increasing its localized density. This denser, colder water consequently sinks downward due to gravity, effectively cooling the entire bottom section through naturally occurring macroscopic convection currents.

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45. When an exposed water pond begins to freeze under a bitterly cold atmosphere, what is the precise sequential sequence of internal temperatures that leads to the final formation of an insulating surface ice layer?
(A) Surface cools to 4°C, denser water sinks, bottom reaches 4°C, surface continues cooling to 0°C and solidifies.
(B) Surface cools to 0°C, expands heavily, sinks immediately, and triggers bottom-up freezing dynamically.
(C) Bottom cools to 0°C, freezes instantly, pushes warmer 4°C water upward, freezing the surface simultaneously.
(D) Entire pond cools symmetrically to 0°C uniformly, triggering a sudden total instantaneous structural freeze.

Ans : (A)

Due to unique thermodynamic principles, descending cold surface water initially chills the bottom layer securely to four degrees Celsius. Subsequently, the remaining topmost liquid layer undergoes anomalous physical expansion upon further cooling, trapping it stably at the surface until it finally freezes solid.

46. According to the kinetic theory governing thermal dynamics, why exactly does a freely heated solid eventually require more physical room for immediate molecular movement?
(A) Heat physically inflates each individual internal atom like a small microscopic elastic balloon.
(B) Rapid thermal vibrations forcibly push

proportionally. When the entire uniform metal sheet is heated, it expands uniformly outward in all directions, causing the central hole to symmetrically increase in size along with the surrounding metal.

21. Consider the following statements regarding the structural setup of Hope's apparatus:
I. It consists of a tall metallic cylinder with two side openings near the top and bottom.
II. A central cylindrical trough strictly contains boiling water to provide uniform heating.
III. Two distinct thermometers are utilised to record temperatures at different varying depths.
IV. The inner metallic cylinder is originally filled with pure water at normal room temperature.
Which of the statements provided above accurately describe the experimental setup?
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I and IV only

Ans : (B)

Hope's apparatus is designed to visually demonstrate the anomalous expansion of liquid water. The central cylindrical trough is specifically filled with a freezing mixture composed of ice and salt to induce localized cooling, rather than utilizing boiling water for arbitrary heating.

22. In Hope's experiment, the central part of the metallic cylinder is surrounded by a cylindrical trough containing a specific mixture. What are the constituent components of this mixture?
(A) Pure crushed ice and cold water
(B) Solid carbon dioxide and liquid nitrogen
(C) A thoroughly blended mixture of ice and salt
(D) A uniformly chilled mixture of alcohol and water

Ans : (C)

The central trough in Hope's apparatus is deliberately packed with a specialized freezing mixture consisting of ice and salt. This combination efficiently produces and maintains a sustained sub-zero temperature environment necessary to successfully cool the internal water column downward through freezing.

23. During the initial phase of Hope's experiment, the reading of the lower thermometer decreases rapidly while the upper thermometer remains largely constant. What mechanism is primarily responsible for this specific observation?
(A) The warmer water at the top transfers its heat downward through rapid conduction.
(B) The central water cools, contracts, increases in density, and consequently sinks to the bottom.
(C) The freezing mixture absorbs heat exclusively from the bottom layer through direct radiation.
(D) The water at the bottom freezes instantly, causing a sudden temperature drop.

Ans : (B)

When the centrally located freezing mixture cools the adjacent water, the water undergoes normal thermal contraction. This resulting increase in density causes the heavier chilled water to sink downward, efficiently replacing the warmer water and rapidly lowering the bottom thermometer's reading.

24. The table shows the approximate percentage increase in volume for a solid, a liquid, and a gas when heated by the same temperature difference ($\Delta T = 50°C$), starting from the same initial volume.

Substance Type	**Initial Volume (cm^3)**	**Temperature Change (DT)**	**Final Volume (cm^3)**
Solid (Steel)	1000	50°C	1001.8
Liquid (Water)	1000	50°C	1010.5
Gas (Air)	1000	50°C	1183.1

What conclusion can be drawn about cubical expansion from this data?
(A) Solids expand more than liquids and gases.
(B) Liquids expand more than gases but less than solids.
(C) Gases exhibit the highest degree of expansion.
(D) All three states of matter expand equally.

Ans : (C)

The data shows that for the same initial volume and temperature change, the gas (air) experiences the largest increase in volume, followed by the liquid (water), and then the solid (steel). This demonstrates that gases undergo the most significant cubical expansion, a result of the weak intermolecular forces allowing molecules to move apart freely.

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51. According to the ten percent law of energy transfer, if a producer holds 10,000 Joules of available energy, what amount of energy will successfully reach the secondary consumer?

(A) 1,000 Joules
(B) 100 Joules
(C) 10 Joules
(D) 1 Joule

Ans : (B)

According to the ten percent law proposed by Raymond Lindeman, only ten percent of the energy is transferred from one trophic level to the next. The remaining energy is utilized for metabolic processes or dissipated into the surrounding environment as heat.

52. The table below shows the density of pure water at various temperatures, reflecting the relationship shown in Fig. 6.3 of the chapter.

Temperature (°C)	Density (g/cm³)
0	0.99987
2	0.99997
4	1.00000
6	0.99997
8	0.99985
10	0.99970

What is the primary conclusion from this data regarding the density of water?
(A) The density of water is maximum at 0°C.
(B) The density of water increases as it is heated from 4°C to 10°C.
(C) The density of water is maximum at 4°C.
(D) The density of water is minimum at 4°C.

Ans : (C)

The data demonstrates that as temperature rises from 0°C, the density of water increases until it reaches its highest value of 1.00000 g/cm³ at 4°C. Beyond 4°C, the density begins to decrease. This property is a direct consequence of water's anomalous expansion, where it has its minimum volume and thus maximum density at 4°C.

53. What is the approximate estimated value of the solar constant representing the average solar energy reaching the upper atmosphere per second on an area of 1 square meter?
(A) 2.50 kW m^{-2}
(B) 1.34 kW m^{-2}
(C) 3.14 kW m^{-2}
(D) 0.60 kW m^{-2}

Ans : (B)

The solar constant represents the average solar energy reaching the upper atmosphere of the earth per second on an area of one square meter. Its estimated value is nearly 1.34 kilowatts per square meter, playing a crucial role in calculations.

54. Read the given assertion and reason carefully, then choose the correct option.
Assertion (A) : A normal food chain usually does not consist of more than five trophic levels.
Reason (R) : According to the ten percent law, the energy available at successive trophic levels decreases progressively and sharply.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

A food chain usually cannot support more than five trophic levels. This occurs because energy is lost as heat during each transfer. The remaining energy at the fifth level is simply not sufficient to sustain any further successive trophic levels.

55. Consider the following statements regarding the flow of energy in an ecosystem:
I. The flow of energy is strictly unidirectional.
II. Secondary consumers directly consume producers to gain energy.
III. Decomposers convert excretory products into heat energy and minerals.
IV. Organisms can create new energy to supplement the food chain.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

Ans : (B)

The first law of thermodynamics states that energy cannot be created or destroyed. The flow of energy is strictly unidirectional from producers to various consumers. Producers do not consume other animals; they trap solar energy to synthesize their own food.

56. Match the ecological roles in List-I with their correct characteristics in List-II.
List-I (Ecological Role)
P. Producers
Q. Primary Consumers

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Ans : (A)

Tidal energy arises from gravitational pulls. Ocean thermal energy relies on temperature differences across ocean depths. Geothermal energy harnesses underground heat trapped in rocks. Biogas relies on the anaerobic decomposition of organic waste materials, converting dead biological matter into fuel.

66. Consider the following statements regarding the construction of high-rise dams for hydroelectricity:
I. It effectively limits the downstream nutrient supply for local fish populations.
II. It generally avoids disturbing the surrounding ecological balance.
III. It can easily be established in virtually any geographic location.
IV. It converts the potential energy of stored water into kinetic energy upon release.
Which of the given statements are factually correct?
(A) I and II
(B) II and III
(C) I and IV
(D) III and IV

Ans : (C)

Constructing high-rise dams for hydroelectricity causes significant ecological damage. Large areas of land become submerged, displacing local plants and animals. Furthermore, the downstream fish population frequently decreases because essential nutrient supplies remain completely trapped inside the newly formed artificial reservoir.

67. Ocean Thermal Energy Conversion (OTEC) plants strictly require a minimum temperature difference between the warm surface water and the colder deep water. What is this necessary temperature difference?
(A) 10 degrees Celsius
(B) 20 degrees Celsius
(C) 30 degrees Celsius
(D) 40 degrees Celsius

Ans : (B)

Ocean thermal energy conversion plants operate by exploiting the natural temperature gradient found in oceans. A minimal temperature difference of twenty degrees Celsius between the sun-heated surface water and the colder deep water is strictly required to successfully generate electricity.

68. The heat energy naturally stored beneath the surface of the earth can be harnessed for power generation. What are the specific locations containing these exceptionally heated underground rocks called?
(A) Magma pockets
(B) Thermal vents
(C) Hot spots
(D) Lava pools

Ans : (C)

Geothermal energy is effectively harnessed by utilizing the heat trapped within underground rocks. These specific geological locations are known as hot spots. Water coming into contact with these exceptionally hot underground regions turns into high-pressure steam, which can rotate turbines.

69. Read the given assertion and reason carefully, then choose the correct option.
Assertion (A) : The sun generates its tremendous amount of daily radiated energy strictly through continuous nuclear fission reactions.
Reason (R) : Nuclear fusion involves the combination of two extremely light nuclei under tremendously high temperatures and pressures.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (D)

The sun generates its tremendous amount of energy strictly through nuclear fusion, not nuclear fission. Nuclear fusion is a distinct process involving the combination of two incredibly light nuclei under extremely high temperature and pressure to form a heavier nucleus.

70. Which highly specific radioactive isotope is predominantly utilized as the primary fuel source within modern commercial nuclear power plants to produce electricity?
(A) Plutonium-241
(B) Uranium-235
(C) Carbon-14
(D) Uranium-238

Ans : (B)

Uranium-235 serves as the primary radioactive fuel utilized within modern nuclear power plants. Unlike conventional fossil fuels, it is not combusted. Instead, it undergoes a highly controlled chain reaction of nuclear fission within a steel pressure vessel to release energy.

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(C) II, III, and IV
(D) I, II, and IV

Ans : (B)

An ideal source of energy must fulfill several fundamental characteristics. It should be entirely safe and convenient to use, capable of providing an adequate amount of useful energy over an extended period, highly economical, and inherently easy to store efficiently.

61. For a windmill to successfully generate a steady and usable amount of electric power, what is the required minimum speed of the blowing wind?
(A) 15 km per hour
(B) 25 km per hour
(C) 35 km per hour
(D) 50 km per hour

Ans : (B)

Wind energy cannot be harnessed effectively at locations where the wind does not blow consistently. For a windmill to operate efficiently and generate usable electric power, the wind speed must be steadily maintained at no less than 25 kilometres per hour.

62. Which sequence best describes the precise energy transformation taking place when a windmill is actively used to generate electricity?
(A) Potential energy -> Kinetic energy -> Heat energy
(B) Kinetic energy -> Rotational kinetic energy -> Electrical energy
(C) Chemical energy -> Kinetic energy -> Rotational kinetic energy
(D) Rotational kinetic energy -> Potential energy -> Electrical energy

Ans : (B)

When blowing wind strikes the blades of a windmill, its kinetic energy is transferred. This changes into the rotational kinetic energy of the blades. The spinning turbine then rotates the armature of a connected dynamo, successfully producing a useful electrical current.

63. Read the given assertion and reason carefully, then choose the correct option.
Assertion (A) : Hydro energy is traditionally considered an indirect source of solar energy.
Reason (R) : Solar energy actively drives the natural water cycle by evaporating surface water, which eventually precipitates in high-altitude regions.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Hydro energy heavily relies on the natural water cycle, which is completely driven by the sun. Solar heat evaporates surface water, forming elevated clouds. When this precipitation falls on mountainous regions, the stored potential energy ultimately converts into harness able kinetic energy.

64. Biogas is widely regarded as an excellent smokeless fuel for household use. Which specific gas serves as the major constituent of biogas, making up approximately seventy percent of its total volume?
(A) Hydrogen sulphide
(B) Nitrogen dioxide
(C) Methane
(D) Carbon monoxide

Ans : (C)

Biogas is predominantly produced through the anaerobic decomposition of biological waste. Methane is the major constituent of this mixture, comprising up to seventy percent of the volume. This high methane content makes biogas an exceptionally excellent and efficient smokeless fuel.

65. Match the alternative energy sources in List-I with their accurate functional descriptions in List-II.
List-I (Energy Source)
P. Tidal Energy
Q. Ocean Thermal Energy
R. Geothermal Energy
S. Biogas Energy
List-II (Description)
I. Relies on temperature differences across ocean depths
II. Arises from gravitational pulls causing sea level changes
III. Harnesses underground heat trapped in deep earth rocks
IV. Relies on the anaerobic decomposition of organic waste
(A) P-II, Q-I, R-III, S-IV
(B) P-I, Q-II, R-IV, S-III
(C) P-III, Q-IV, R-I, S-II
(D) P-II, Q-IV, R-III, S-I

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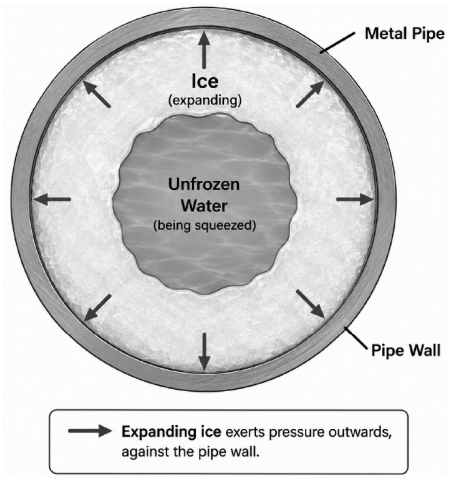
R. Secondary Consumers
S. Decomposers
List-II (Characteristic)
I. Carnivores that consume herbivores
II. Micro-organisms that degrade dead remains
III. Photosynthetic organisms that synthesize food
IV. Herbivores that directly eat plants
(A) P-III, Q-IV, R-I, S-II
(B) P-IV, Q-III, R-II, S-I
(C) P-III, Q-I, R-IV, S-II
(D) P-II, Q-IV, R-I, S-III

Ans : (A)

Solar energy initiates the process by allowing plants to synthesize food. Herbivores directly consume these producers, making them primary consumers. Carnivores eat herbivores, placing them at the secondary consumer level. Decomposers break down dead remains into simple minerals and heat.

57. The diagram shows a cross-section of a water pipe during a very cold night. Which statement best explains why such pipes are likely to burst?



(A) The metal pipe contracts in the cold, squeezing the water inside.
(B) The water, as it cools from 4°C to 0°C and freezes, expands in volume.
(C) The water pressure from the main supply increases dramatically during winter.
(D) The frozen water becomes much heavier, causing the pipe to break under its weight.

Ans : (B)

Water exhibits anomalous expansion when it cools from 4°C to 0°C. Upon freezing into ice at 0°C, it expands even more, by about 9% in volume. This expansion within the confined space of a pipe exerts an immense pressure on the pipe walls, which can exceed the pipe's structural strength and cause it to rupture.

58. A simple solar cell consists of a semiconductor sandwich. Which specific materials are traditionally utilized as impurity layers on the top and bottom of the central silicon structure?
(A) Copper and zinc layers
(B) Iron and nickel layers
(C) Boron and arsenic layers
(D) Aluminium and lead layers

Ans : (C)

A basic solar cell consists of a sandwich structure utilizing a silicon-boron layer alongside a silicon-arsenic layer. Boron and arsenic serve as impurities added in minute quantities to semiconducting silicon, thereby facilitating the generation of an electric current under sunlight.

59. Read the given assertion and reason carefully, then choose the correct option.
Assertion (A) : A solar panel cannot generate maximum electricity on a highly cloudy day.
Reason (R) : The energy conversion efficiency of solar cells is very high and depends entirely on the ambient room temperature.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

A solar panel produces less electricity on a cloudy day because it requires direct sunlight for optimal operation. Furthermore, the inherent energy conversion efficiency of solar cells is relatively low, typically converting only about twenty-five percent of incident light energy.

60. Consider the following statements about the ideal characteristics of a good source of energy:
I. It should be capable of providing an adequate amount of useful energy over a long period.
II. It should emit significant amounts of carbon dioxide to maintain environmental balance.
III. It should be fully economical and exceptionally easy to store safely.
IV. It should be completely safe and convenient for daily use.
Which of the given statements represent correct characteristics?
(A) I, II, and III
(B) I, III, and IV

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71. Inside a nuclear power plant reactor, the massive amount of energy generated by fission must be regulated to prevent overheating. Which specific structural component is used to control this chain reaction?
(A) Graphite shield
(B) Water pump
(C) Steel turbine
(D) Cadmium rods

Ans : (D)

Within a nuclear reactor, the fission chain reaction must be precisely maintained to prevent catastrophic meltdowns. Cadmium rods are specifically utilized to absorb excess neutrons, thereby effectively controlling the overall rate of the continuous nuclear chain reaction inside the vessel.

72. In continuation of Hope's experiment, the temperature T_1 at the top of the cylinder is also recorded. T_2 has already stabilized at 4°C.

Time (minutes)	Temperature T1 (°C)
15	12
20	9
25	5
30	1
35	0

What causes the temperature T_1 to start decreasing rapidly after T_2 has stabilized?
(A) Heat is now conducted downwards from the top layer.
(B) Water cooled below 4°C becomes less dense and rises to the top.
(C) The top layer starts to freeze immediately after the bottom reaches 4°C.
(D) The entire column of water begins to cool uniformly.

Ans : (B)

Once the lower section is at 4°C, further cooling of the central section causes the water's temperature to fall below 4°C. Due to anomalous expansion, this cooler water becomes less dense. Consequently, it rises to the top, causing the temperature recorded by thermometer T_1 to decrease steadily towards 0°C.

73. Consider the following statements distinguishing renewable and non-renewable energy sources:
I. Renewable natural sources are inexhaustible and can supply energy continuously.
II. Non-renewable sources represent conventional forms of energy heavily used today.
III. Fossil fuels can be easily regenerated within short intervals of time.
IV. Petroleum and natural gas are inexhaustible resources found deep underground.
Which of the provided statements are entirely correct?
(A) I and II
(B) II and III
(C) I and IV
(D) III and IV

Ans : (A)

Renewable energy sources are generally inexhaustible and can be harnessed continuously over a long span of time. Conversely, non-renewable energy sources, such as coal and petroleum, are exhaustible and cannot be quickly regenerated once their deeply buried reserves are completely depleted.

74. Coal is a naturally occurring combustible solid formed over millions of years. Which of the following correctly lists the four primary geological types of extracted coal?
(A) Anthracite, bitumin, tar, lignite
(B) Anthracite, bituminous, subbituminous, lignite
(C) Bituminous, subbituminous, coke, charcoal
(D) Lignite, graphite, bituminous, pure carbon

Ans : (B)

Coal is a naturally occurring combustible solid composed predominantly of complex carbon compounds. It is commonly found in four primary geological types: anthracite, bituminous, sub-bituminous, and lignite. Extracting this valuable fossil fuel heavily disturbs the surrounding land and local ecosystems.

75. In a structured ecological food chain, primary consumers are distinctly recognized from secondary consumers. Which fundamental characteristic accurately describes primary consumers?
(A) They hunt and completely consume other carnivorous animals.
(B) They consist entirely of micro-organisms degrading dead animal remains.
(C) They are herbivores that directly consume green photosynthetic plants.
(D) They synthesize complex chemical food using direct atmospheric sunlight.

Ans : (C)

Primary consumers, commonly referred to as herbivores, sustain themselves by directly eating producers like green plants. Secondary consumers,

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functioning as carnivores, subsequently hunt and consume these primary consumers. This sequence ensures the continuous transfer of energy throughout the entire ecosystem.

76. Crude petroleum oil pumped from underground reservoirs contains various harmful impurities like sulphur and sand. Which industrial procedure is utilized to refine these mixed components into highly useful liquid fuels?
(A) Subjecting the crude oil to extremely high mechanical pressure
(B) Exposing the crude oil directly to concentrated solar radiation
(C) Heating the crude oil carefully within a tall distillation tower
(D) Passing an alternating electric current through the crude liquid

Ans : (C)

Crude oil is a naturally occurring, dark brown liquid extracted from underground reservoirs. Since it contains numerous impurities like sulphur and sand, it must be refined. This separation process is accomplished by carefully heating the crude oil in a distillation tower.

77. Liquid Petroleum Gas (LPG) contains a highly flammable mixture of hydrocarbon gases. Which powerful chemical odorant is intentionally added to the cylinder to quickly detect any accidental and potentially dangerous leaks?
(A) Ethanethiol
(B) Hydrogen sulphide
(C) Methane gas
(D) Nitrogen dioxide

Ans : (A)

Liquid petroleum gas consists primarily of a highly flammable mixture of hydrocarbon gases, specifically propane and butane. Because these gases are naturally odorless, a powerful odorant called ethanethiol is intentionally added to ensure that dangerous accidental leaks are detected immediately.

78. Read the given assertion and reason carefully, then choose the correct option.
Assertion (A) : The constant and unmonitored consumption of conventional fossil fuels will likely create a severe global energy crisis in the near future.
Reason (R) : Fossil fuels are exhaustible, non-renewable natural resources that require millions of years to completely form deep beneath the crust.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Fossil fuels are strictly non-renewable resources that require millions of years to naturally form deep underground. Because their overall supply is highly limited, excessive and careless consumption will inevitably lead to a severe global energy crisis in the near future.

79. To promote the judicious use of energy, households are highly encouraged to adopt efficient construction practices. Which method effectively minimizes the required energy used for continuous indoor heating and cooling?
(A) Removing external structural walls
(B) Proper insulation of houses
(C) Keeping all windows constantly open
(D) Utilizing traditional incandescent light bulbs

Ans : (B)

To ensure the judicious use of energy, households should adopt highly efficient conservation practices. Proper insulation of homes is highly recommended because it significantly reduces the amount of heating and cooling energy required to maintain a comfortable indoor temperature year-round.

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80. The first law of thermodynamics strictly dictates that energy can neither be created nor destroyed. How is this fundamental physical law directly demonstrated within an ecological food chain?
(A) Decomposers create massive amounts of heat energy independently.
(B) Green plants successfully capture incoming sunlight and efficiently convert it into usable chemical energy.
(C) Consumers inherently destroy all the thermal energy they ingest.
(D) Fungi actively synthesize fresh solar energy underground.

Ans : (B)

The first law of thermodynamics explicitly dictates that energy cannot be created. In any food chain, green plants cannot spontaneously generate energy. Instead, they capture incoming sunlight and efficiently convert it into usable chemical energy through the complex process of photosynthesis.

81. Consider the following statements regarding the inherent limitations of employing renewable energy sources:

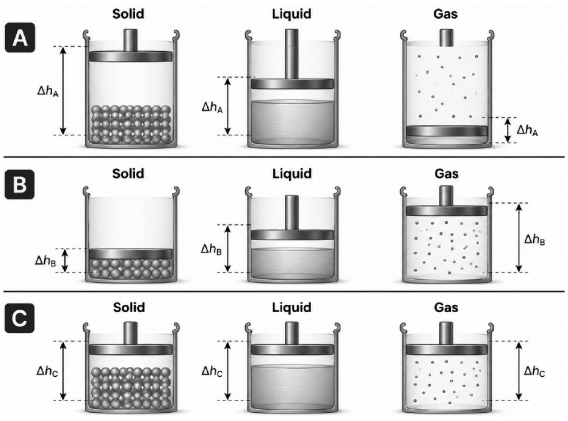
I. Solar panels strictly require direct sunlight for achieving maximum conversion efficiency.
II. Wind energy farms can easily operate efficiently in completely windless atmospheric conditions.
III. Hydroelectric dams often drastically disturb the surrounding local ecological balance.
IV. Nuclear waste produced during power generation is entirely harmless and biodegradable.

Which of the provided statements correctly describe genuine limitations?
(A) I and III
(B) I and II
(C) II and IV
(D) III and IV

Ans : (A)

Both solar and wind energy technologies possess distinct operational limitations. Solar panels only function effectively during daylight and suffer reduced efficiency on cloudy days. Similarly, wind farms require vast expanses of land and continuous wind speeds exceeding twenty-five kilometers per hour.

82. Three identical cylinders with frictionless pistons contain a solid, a liquid, and a gas, all at the same initial volume and temperature. If the same amount of heat is supplied to each, which diagram correctly shows the likely result?



(A) Diagram A
(B) Diagram B
(C) Diagram C
(D) Both A and C are possible depending on the substance.

Ans : (B)

Explanation: For a given increase in temperature, gases expand significantly more than liquids, and liquids expand more than solids. This is because the intermolecular forces in gases are weakest, allowing for the greatest increase in volume. Diagram B correctly depicts this relative thermal expansion, showing the largest volume change for the gas and the smallest for the solid.

83. Which term precisely describes the specific chemical energy that is naturally stored within the biological waste and dead structural parts of living beings?
(A) Geothermal energy
(B) Nuclear energy
(C) Bioenergy
(D) Tidal energy

Ans : (C)

Biomass consists of the biological waste and dead structural parts of living beings, including plants and animals. The specific chemical energy naturally stored within these organic materials is formally known as bioenergy, which ultimately derives its initial origin from sunlight.

84. Due to the continuous blowing of planetary winds on the surface of oceans, waves inherently move at exceptionally high speeds. What specific form of energy do these rapidly moving oceanic waves possess?
(A) Vast amounts of kinetic energy
(B) Substantial gravitational potential energy
(C) Concentrated ocean thermal energy
(D) Internal geothermal thermal energy

Ans : (A)

Oceanic waves travel at incredibly high speeds across the water surface due to continuous wind action. Because of this rapid movement, these oceanic waves carry a massive amount of kinetic energy, which can be mechanically harnessed to generate useful electricity.

85. Which statement correctly highlights the massive energy difference between a nuclear fission reaction and conventional chemical combustion?
(A) Fission of one uranium-235 atom yields half the energy of burning one carbon atom.
(B) Burning one carbon atom releases ten million times more energy than fission.
(C) Fission of one uranium-235 atom yields ten million times more energy than burning one carbon atom.
(D) Both processes release the exact same amount of thermal energy.

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The expansion of a substance on heating is called the thermal expansion of the substance.

102. What is heat ? Write its S.I. unit.

Ans :

Heat is a form of energy that flows from a hotter body to a colder body due to a temperature difference.
S.I. unit: Joule (J)

103. At what temperature the density of water is maximum ? State its value.

Ans :

Density of water is maximum at $4C$.
Value of density is 1 g cm -3 or 1000 kg m^{-3}

104. Two bodies at different temperatures are placed in contact. State the direction in which heat will flow.

Ans :

Heat will flow from the body at higher temperature to the body at lower temperature until both reach the same temperature.

105. Name the S.I. unit of heat and how is it related to the unit of calorie?

Ans :

The S.I. unit of heat is joule or J. It is related to calorie as follows:
1 cal = 4.186 J (or nearly 4.2 J)

106. Define temperature and write its S.I. unit.

Ans :

Temperature is the measure of the degree of hotness or coldness of a body.
The S.I. unit of temperature is kelvin or K.

107. What do you mean by anomalous expansion of water?

Ans :

The expansion of water when it is cooled from $44C$ to VC, is called as anomalous expansion of water.

108. Why is the use of wood as a fuel not advisable although wood is a renewable source of energy ?

Ans :

Use of wood is renewable source, but is not advised to use, because saplings take a long time to become a tree.

109. What will be the effect of global warming at the poles?

Ans :

Due to global warming the snow and ice around the poles will melt and cause floods in coastal countries.

110. Name five renewable and three non-renewable sources of energy.

Ans :

Renewable sources : Solar energy, wind energy, hydro-energy, geo thermal energy and nuclear energy.
Non-renewable sources : Coal, petroleum and natural gas.

111. What results in the increase of carbon dioxide contents of the earth's atmosphere ?

Ans :

Burning of fossil fuels and clearing of forests results in the increase of carbon dioxide contents of the earth's atmosphere.

112. What do you mean by global warming ?

Ans :

The increase in the average temperature of earth's surface due to an increase in the amount of green house gases in its atmosphere is called global warming.

113. What is a food chain ?

Ans :

A series of organisms depending on one another for their food requirements forms a food chain.

114. Name three green house gases.

Ans :

(i) Carbon dioxide,
(ii) Methane, and
(iii) Water-vapours.

NODIA

115. The conversion of part of energy into an useful form of energy is called

Ans :

The conversion of part of energy into an useful form of energy is called degradation of energy.

116. Which of the following solar radiations pass through the atmosphere of earth :
X - rays, ultraviolet rays, visible light rays,

generate crucial electrical power supplies.

91. Tidal energy requires distinct geographical conditions to be effectively harnessed. Which set of coastal sites within India has been specifically identified for successfully setting up tidal energy extraction projects?
(A) Gulf of Kutch, Gulf of Cambay, and Sunderbans
(B) Tarapur, Narora, and Kaiga
(C) Thar Desert, Jaisalmer, and Bikaner
(D) Shimla, Manali, and Himachal Pradesh

Ans : (A)

Tidal energy requires highly specific geographical locations featuring significant periodic sea level variations. Within India, the most suitable sites identified for harnessing this powerful kinetic energy are the Gulf of Kutch, the Gulf of Cambay, and the coastal Sunderbans region.

92. An energy pyramid graphically represents the sequential flow of energy throughout an ecosystem. Why does the fundamental shape of this energy pyramid continuously become narrower towards the apex?
(A) Producers physically outnumber decomposers at higher levels.
(B) Available energy progressively decreases at each successive trophic level.
(C) Carnivores inherently possess far greater body mass than producers.
(D) Herbivores actively destroy solar energy before it reaches the top.

Ans : (B)

The standard energy pyramid graphically demonstrates how available energy decreases progressively across successive trophic levels. Consequently, producers structurally form the broad base of this pyramid, while the higher levels become increasingly narrower towards the apex due to continuous thermal energy dissipation.

93. A solar cell functions as a remarkably unique technological device because it entirely bypasses the intermediate mechanical heating stages. What is the exact energy transformation achieved by this device?
(A) Solar energy directly into chemical energy
(B) Chemical energy directly into rotational kinetic energy
(C) Solar energy directly into electrical energy
(D) Potential energy directly into thermal heat energy

Ans : (C)

A solar cell, frequently referred to as a photovoltaic cell, provides a remarkably unique technological function. It bypasses intermediate mechanical steps, managing to convert incident solar energy directly into usable electrical energy by exploiting the specialized properties of semiconducting materials.

ONE MARK QUESTIONS

94. Name two substances which expand on heating.

Ans :

Iron, water expand on heating.

95. Name two substances which contract on heating. ;

Ans :

Ice, silica below - 804 contract on heating.

96. What is the source of energy for all ecosystems?

Ans :

Sun is the source of energy for all ecosystems.

97. What is the main source of energy for the earth ?

Ans :

Sun is the main source of energy for earth.

98. State the effect of global warming in coastal regions.

Ans :

Global warming will cause floods in coastal regions.

99. How will global warming affect the sea level ?

Ans :

Global warming will lead to rise in sea-level.

100. How will global warming affect the agriculture ?

Ans :

Global warming will result in low agriculture yield.

101. What do you understand by thermal expansion of a substance?

Ans :

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Ans : (C)

Nuclear fission is a highly energetic reaction involving the splitting of a heavy nucleus. In fact, the fission of a single uranium-235 atom yields an astounding ten million times more energy than the simple combustion of one atom of carbon.

86. Natural gas is often discovered deeply trapped in underground reservoirs situated above major crude oil deposits. What does the common commercial abbreviation CNG stand for?
(A) Combustible Natural Gas
(B) Compressed Natural Gas
(C) Cooled Natural Gas
(D) Carbonized Natural Gas

Ans : (B)

Natural gas is frequently discovered trapped in underground reservoirs above oil deposits. Composed predominantly of methane, it is highly flammable and burns cleanly. When subjected to high pressure, it forms compressed natural gas, serving as an excellent fuel for vehicles.

87. What specific scientific term defines the immense natural temperature difference that exists between the incredibly hot core of the planet and its cooler outer surface layer?
(A) Geothermal gradient
(B) Ocean thermal differential
(C) Potential energy shift
(D) Atmospheric thermal gradient

Ans : (A)

The geothermal gradient refers to the natural difference in temperature between the remarkably hot planetary core and the outer surface. This phenomenon continuously drives the outward conduction of thermal energy, systematically heating underground rocks to form harness able geothermal hot spots.

88. To minimize everyday fuel consumption and maximize vehicle fuel efficiency, which simple mechanical adjustment can significantly reduce detrimental tire-to-road friction?
(A) Operating advanced household boilers at higher temperatures
(B) Removing all interior insulation from the vehicle cabin
(C) Maintaining vehicle tires properly inflated to the correct pressure
(D) Keeping modern automobile engines running idly at all times

Ans : (C)

Implementing modern energy-saving strategies is absolutely vital for global environmental sustainability. Using advanced LED lights drastically reduces household power consumption. Similarly, maintaining correctly inflated vehicle tires successfully lowers rolling friction, thereby improving overall fuel economy by up to three percent.

89. Although nuclear power generates massive amounts of electrical energy using minimal fuel, it possesses significant environmental limitations. What is the primary ecological disadvantage associated with nuclear power generation?
(A) It emits vast volumes of atmospheric greenhouse gases like methane.
(B) It fully relies on continuous daylight and clear weather conditions.
(C) The highly radioactive nuclear waste produced poses severe biological risks.
(D) It requires constructing expansive dams that flood vast geographical areas.

Ans : (C)

While nuclear energy yields massive amounts of power from minimal fuel, it possesses significant environmental drawbacks. The generated nuclear waste remains highly radioactive in nature, posing severe biological risks to all living beings and necessitating extremely careful, long-term disposal strategies.

90. Match the active Indian nuclear power plant locations in List-I with their respective states in List-II.
List-I (Power Plant Location)
P. Tarapur
Q. Rana Pratap Sagar
R. Kalpakkam
S. Narora
List-II (State)
I. Rajasthan
II. Tamil Nadu
III. Uttar Pradesh
IV. Maharashtra
(A) P-IV, Q-I, R-II, S-III
(B) P-III, Q-I, R-IV, S-II
(C) P-I, Q-IV, R-II, S-III
(D) P-IV, Q-II, R-I, S-III

Ans : (A)

India effectively operates multiple nuclear power plants across various states. Tarapur is situated in Maharashtra, Rana Pratap Sagar is located in Rajasthan, Kalpakkam operates in Tamil Nadu, and Narora functions safely in Uttar Pradesh to

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infrared radiations.

Ans :

Visible light rays and infra-red radiation.

117. What would have been the temperature of earth's atmosphere in absence of green house gases in it?

Ans :

The temperature of earth's atmosphere would have been $-18^{\circ}C$ in the absence of green house gases in it

118. State the importance of green plants in an ecosystem.

Ans :

Plants absorb most of the part of sunlight falling on them in the form of energy. This helps to show the energy flow in ecosystem.

119. State the cause of increase of green house effect.

Ans :

The cause of increase of green house effect is the increase in the concentration of green house gases (carbon dioxide, methane, chlorofluorocarbons etc.) in the atmosphere.

120. Deep pond of water has its top layer frozen during winter. State the expected temperature of water layer (i) just in contact with ice, (ii) at the bottom of pond.

Ans :

(i) Temperature of water layer just in contact with ice is VC.
(ii) At the bottom of pond is VC.

121. What is an ecosystem ? Name its two components.

Ans :

An ecosystem is a system where living organisms interact with each other and with their physical (non-living) environment.
Two components :
(i) Biotic components comprising living.
(ii) Abiotic components comprising non-living or physical factors.

122. What do you mean by green house effect ?

Ans :

The process by which absorption and emission of infra-red radiation by the atmospheric gases warm up the surface of a planet and its lower atmosphere is called green-house effect.

123. Why does a piece of ice when touched with hand, appears cold ? Explain.

Ans :

A piece of ice appears cold when touched because heat flows from our hand (higher temperature) to the ice (lower temperature).This loss of heat from our body makes our skin feel cold.

TWO MARKS QUESTIONS

124. State two characteristics which a source of energy must have.

Ans :

A source of energy should be such that it can provide an adequate amount of useful energy at a steady rate over a longer period of time. It is safe, convenient to use, economical and easy to store and transport.

125. What is carbon tax ? Who will pay it ?

Ans :

A Tax impressed by Govt. to discourage emission of carbon-dioxide into atmosphere and to encourage the industry to use energy efficient office and to avoid the travelling of its employees by having the teleconferencing, the industry be imposed carbon tax The industry should pay the carbon tax.

NODIA

126. What causes the rise in atmospheric temperature?

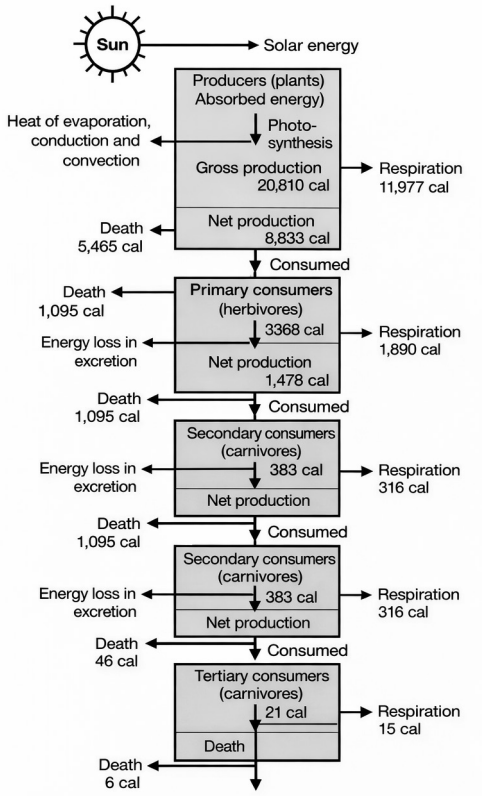
Ans :

Rise in atmospheric temperature is caused by the trapping of infra-red radiations of long wavelength emitted from earth's surface by green house gases like carbon dioxide, methane, water vapour and chlorofluorocarbons.

127. Give two examples each of biotic and abiotic components.

Ans :

Biotic components refer to the living organisms in an ecosystem, while abiotic components refer to the non-living physical and chemical factors that influence the ecosystem.
Two examples of biotic components are Plants and Animals
Two examples of abiotic components are water and soil

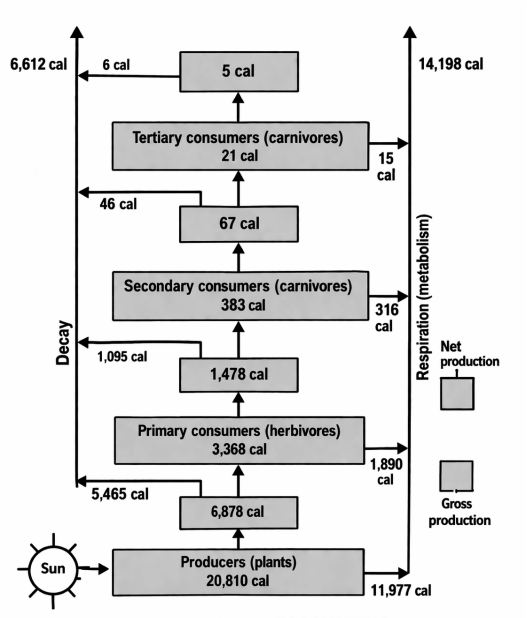


ENERGY FLOW IN ECOSYSTEM IN FORM OF A FOOD CHAIN

162. Draw a diagram to show that the energy flow in an ecosystem is governed by the law of conservation of energy.

Ans :

Diagram showing energy flow in ecosystem.



ENERGY FLOW IN ECOSYSTEMS

163. State, in detail, the causes of global warming.

Ans :

Global warming refers to the long-term increase in the Earth's average surface temperature, primarily caused by the release of greenhouse gases, such as carbon dioxide, methane, and water vapour, into the atmosphere. These greenhouse gases trap heat from the sun, causing a warming effect on the Earth's surface.

The causes of global warming are :

1. **Burning of fossil fuels :** The burning of coal, oil, and natural gas releases large amounts of carbon dioxide into the atmosphere. These greenhouse gases trap heat and cause the Earth's temperature to rise.
2. **Deforestation :** Trees absorb carbon dioxide from the atmosphere through photosynthesis. When forests are cut down or burned, the stored carbon is released back into the atmosphere, increasing the amount of greenhouse gases.
3. **Agriculture :** Livestock farming and the use of fertilizers in agriculture release large amounts of methane, which is a potent greenhouse gas.
4. **Industrial processes :** The production of cement and other industrial processes release large amounts of carbon dioxide and other greenhouse gases into the atmosphere.

164. What technological measures are necessary to minimise the impact of global warming?

Ans :

There are a number of technological measures that can be implemented to minimize the impact of global warming. These include:

1. **Renewable energy sources :** Shifting to renewable energy sources such as solar, wind, hydro, and geothermal power can significantly reduce greenhouse gas emissions. Governments can promote and incentive the use of renewable energy by investing in research and development, subsidizing renewable energy, and implementing policies that encourage their use.
2. **Energy efficiency :** Improving energy efficiency in buildings, transportation, and industrial processes can help reduce greenhouse gas emissions. This can be achieved through the use of energy-efficient appliances, smart thermostats, LED lighting, and improved insulation.
3. **Carbon capture and storage :** Carbon capture and storage (CCS) technologies can help

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(iii) Efforts must be made to make use of energy for community purposes.
(iv) Grow more trees. Cutting of trees should be banned.

136. Name the two groups in which various sources of energy are classified. State on what basis are they classified.

Ans :

Classification of Sources of Energy
(i) Renewable or Non-Conventional Source of energy.
(ii) Non-renewable sources or Conventional Source of energy.
The basis of classification is Availability of the source of energy i.e., the source should be such that it can provide an adequate amount of useful energy at a steady rate over a longer period of time. It should be safe, easy to store and transport.

137. Describe the energy flow in an ecosystem.

Ans :

Energy flow is unidirectional plants and some bacteria (blue green algae) absorb most part of sun light falling on them in the form of energy. A part of energy absorbed (only 0.02%) energy is used in photosynthesis. At every step (Trophic Level) a part of energy is used for respiration. A part of energy is wasted. in their decay and decomposition. The energy stored in plants is called Gross Primary Production. A part of energy is wasted in their decay and the remaining part of energy called Net Primary Production is stored as food and used by next higher tropic level.

138. State the energy transformation in the following :
(i) Electricity is obtained from solar energy.
(ii) Electricity is obtained from wind energy.
(iii) Electricity is obtained from hydro energy.
(iv) Electricity is obtained from nuclear energy.

Ans :

(i) Heat energy of sun is used to generate electricity.
(ii) Kinetic energy of winds is used to generate electricity.
(iii) Kinetic energy of flowing water is used to generate electricity.
(iv) Nucleus energy is used to generate electricity.

139. State two advantages and two limitations of using wind energy for generating electricity.

Ans :

Advantages of using wind energy to generate electricity are as follows :
(i) It does not cause any kind of pollution.
(ii) It is a renewable source.
Disadvantages of using wind energy to generate electricity are as follows :
(i) The wind farms can be establishes only at places when wind blows around the year steadily.
(ii) A large area of land is needed to establish a wind farm.

NODIA

140. What is nuclear energy ? Name the process used for producing electricity using the nuclear energy.

Ans :

The energy produced by the nucleus of an atom is called nuclear energy.
Process : Nuclear fission.
Principle : When a heavy nucleus is bombarded with slow neutrons its splits into two nearly equal light nuclei with a release of tremendous amount of energy.
$E = mc^2$ where c is the speed of light.

141. State the effect of green house effect on the temperature of earth's atmosphere.

Ans :

The impact of global warming on the life on earth is as below :
(i) The variable changes in the climate in different parts of the world has created difficulty and forced the people and animals to migrate from one place to the other.
(ii) If has affected the blooming season of the different plants.
(iii) The climatic changes has shown the immediate effect on simple organism and plants.
(iv) It has affected the world's ecology.
(v) It has increased the heat stroke deaths.

142. What is (i) tidal, (ii) ocean and (iii) geo-thermal energy ? Explain in brief.

Ans :

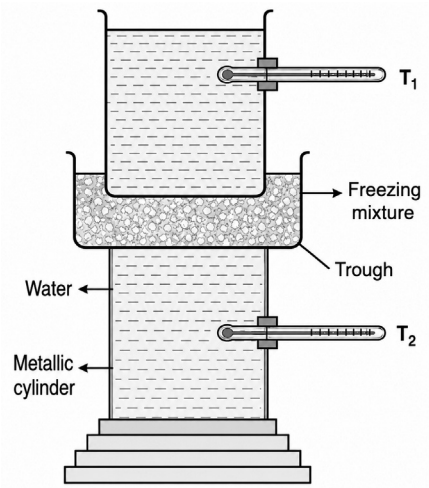
(1) **Tidal :** The energy possessed by rising and falling water in tides is known as tidal energy.
(ii) **Ocean :** Oceans possesses energy in two forms:
(a) Ocean thermal energy : The energy available due to difference in temperature of water at the surface and at deeper levels of oceans is called the ocean thermal energy (OTE).
(b) Oceanic waves energy : The kinetic energy possessed by fast moving oceanic

into ice and its volume increases. Since water when cooled from 4°C to 0°C expands. Thus, exerts large pressure and glass bottle bursts.

167. Describe an experiment to show that water has maximum density at 4°C. What important consequences follow from this peculiar property of water ? Discuss the importance of this phenomenon in nature.

Ans :

Water has maximum density at 4°C can be demonstrated by Hope's apparatus. It consists of a metallic cylinder having trough at middle of it for placing ice or freezing mixture in it. Two thermometers T_1 and T_2 are inserted near the top and bottom to record temperature of water in cylinder. The cylinder is filled with water nearly at 10°C. We see that both thermometers show the same temperature. Freezing mixture of salt and ice is put in the trough.



HOPE'S APPARATUS

Observations.

(i) In the beginning, the thermometer T_1 does not show change in reading.

(ii) When T_2 shows reading at 4°C, it becomes steady and that of upper thermometer begins to fall till 0°C. T_2 still showing 4°C.

(iii) After sometime a thin crust of ice is formed on the top of water in cylinder.

Consequences of Anomalous Expansion of water.

(i) Frost bite is the result of Anomalous expansion of water present in the cells of human beings [especially in the exposed parts] freezes and in doing so bursts open the cells.

(ii) Vegetables, fruit and plants get damaged in severe cold because water present in the plant cells on freezing expands and bursts open the cell walls.

Importance of anomalous expansion of water in nature.

This phenomenon helps preserving aquatic life in very cold weather as water freezes only on the surface and water below stays at 4°C. Thus fish and other aquatic life can easily survive in frozen water bodies.

CASE BASED QUESTIONS

168. Kavita visits a large high-rise dam built across a river valley. She observes a massive reservoir of water stored behind the massive concrete walls. She learns that the stored water is allowed to fall from a significant height onto a mechanical device installed at the bottom of the structure. She records that this process generates no pollution and serves multiple societal needs, but she also notices the submerged forests and relocated local wildlife.

(a) Describe the complete sequence of energy conversions taking place from the stored water to the generation of electricity.

(b) State two specific ecological disadvantages caused by the construction of this large structure.

Ans :

(a) 1. The flowing water in the river is collected in the dam, converting kinetic energy into potential energy stored behind the concrete wall.

2. When allowed to fall, the potential energy changes to rotational kinetic energy of the turbine, which rotates the generator shaft to produce electricity.

(b) 1. The ecological balance gets disturbed due to the construction of a dam as the plants and animals of that specific place get heavily affected.

2. The population of fishes downstream gets reduced because the essential nutrient supply remains trapped in the reservoir formed by the high-rise dam.

169. Sunita lives in a very cold hilly region where winter temperatures frequently drop well below $0^{\circ}C$ during the night. During one particularly severe winter night, she is suddenly awakened by a loud cracking noise outside her window. She goes outside the next morning and discovers that the

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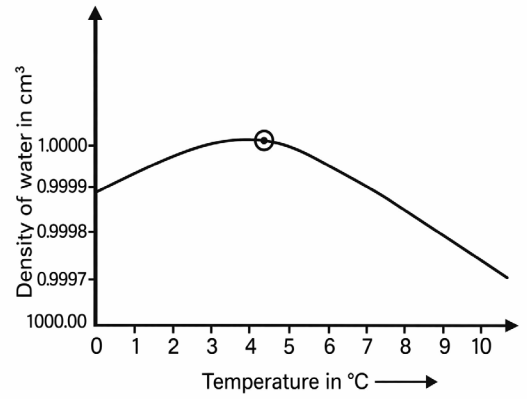
Ans :

The three kinds of thermal expansion are linear expansion, area expansion, and volume expansion. Linear expansion is an increase in length of a solid material when its temperature is raised, while area expansion is an increase in the surface area of a material, and volume expansion is an increase in the overall volume of a material.

Solids generally expand less than liquids and gases because the intermolecular forces holding solids together are stronger, making them more resistant to thermal expansion. Liquids expand more than solids but less than gases, and gases generally expand the most due to their low density and weak intermolecular forces.

149. Draw a graph to show the variation in density of water with temperature in the temperature range OQC to 10°C.

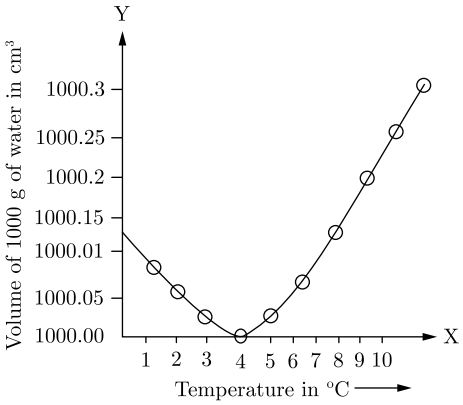
Ans :



150. State the volume changes observed when a given mass of water is heated from 0°C to 104°C. Sketch a temperature-volume graph to show the behaviour.

Ans :

On heating water from 0°C to 4°C it contracts instead of expanding. On heating further above 5°C to 104°C its volume increases.



151. Differentiate between the producers and consumers.

Ans :

Difference between the producers and consumers are as follows :

Producers

(i) Are also called Photosynthetic plants. They produce their food by photosynthesis. Some bacteria are also producers.

(ii) The producers themselves first use the synthesized organic substances in the process of respiration in which some energy is used in oxidation of organic substances.

(iii) Gross production by producers is 20810 cal, out of which 11977 cal is used in respiration.

Consumers

(i) Herbivores (primary consumers) consume the plants or get their food prepared by plants.

(ii) A small part of energy obtained by the primary consumers is utilized in respiration through which they perform metabolic processes.

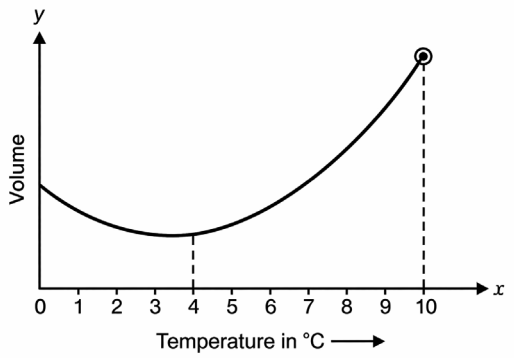
(iii) The primary consumers obtain only 3368 cal. from producers out of which 1890 cal is used up in respiration.

152. A given mass of water is cooled from 10°C to 0°C. State the volume changes observed. Represent these changes on a temperature-volume graph.

Ans :

When water is cooled from 10°C to 4°C its volume decreases, but cooling below 4°C to 0°C, its volume increases instead of decreasing.

NODIA



153. What are primary, secondary and tertiary consumers?

Ans :

In an ecosystem, there are three main types of consumers: primary consumers, secondary consumers, and tertiary consumers. These

consumers play important roles in the food chain, as they obtain their energy by consuming other living organisms.

1. **Primary consumers :** These are herbivores that eat plants. Examples of primary consumers include cows, rabbits, and deer. Primary consumers are the first link in the food chain, and they convert the energy in plants into a form that can be used by other organisms in the ecosystem.
2. **Secondary consumers :** These are carnivores that eat herbivores. Examples of secondary consumers include snakes, owls, and lions. Secondary consumers obtain their energy by consuming primary consumers, and they help to control the population of herbivores in the ecosystem.
3. **Tertiary consumers :** These are carnivores that eat other carnivores. Examples of tertiary consumers include eagles, sharks, and polar bears. Tertiary consumers obtain their energy by consuming secondary consumers, and they play an important role in regulating the populations of other carnivores in the ecosystem.

154. The energy transfer in an ecosystem is not 100% efficient. Why ?

Ans :

The energy transfer in an ecosystem is not 100% efficient for several reasons:

1. **Heat loss :** As organisms consume food, some of the energy is used for their own life processes (such as movement and reproduction) and is converted into heat, which is lost to the environment. This means that not all of the energy is available for transfer to the next trophic level in the food chain.
2. **Incomplete digestion :** Not all of the food that is consumed by an organism can be fully digested and absorbed, so some of the energy in the food is lost in the faeces.
3. **Respiration :** All living organisms need to respire to stay alive, which means they use some of the energy they obtain from their food to power their own metabolic processes. This energy is also lost to the environment.

These factors mean that energy transfer in an ecosystem is never 100% efficient, and the amount of energy available at each trophic level decreases as you move up the food chain. This is why ecosystems typically have more biomass at lower trophic levels and fewer organisms at higher trophic levels.

155. From where do the tertiary consumers obtain their energy?

Ans :

Tertiary consumers obtain their energy by consuming other consumers, such as secondary consumers and primary consumers.

In an ecosystem, primary consumers are herbivores that eat plants, while secondary consumers are carnivores that eat herbivores. Tertiary consumers are carnivores that eat other carnivores. This means that the energy they obtain is passed up the food chain from the plants, to the herbivores, to the carnivores, and finally to the tertiary consumers.

For example, in a simple food chain, grass is eaten by a mouse (a primary consumer), which is in turn eaten by a snake (a secondary consumer), which is then eaten by a hawk (a tertiary consumer). The energy from the grass is passed up the food chain to the hawk through the snake, which ate the mouse, which ate the grass. Tertiary consumers occupy the highest trophic level in a food chain, and typically have a smaller population size and lower biomass compared to lower trophic levels.

156. What is meant by the renewable and non-renewable sources of energy ? State two differences between them, giving two examples of each.

Ans :

The natural sources of energy which can provide energy continuously are called renewable sources of energy.
e.g., (i) Solar energy (ii) wind energy.
Non-renewable sources of energy : The sources of energy which have accumulated in nature over a very long time and cannot be quickly replaced when exhausted, are called non-renewable sources of energy.
e.g., (i) Petroleum (ii) Coal
Difference between Renewable and non-renewable sources are as follows

	Renewable sources	**Non-renewable sources**
1.	These are the sources from which energy can be obtained continuously over a long period of time.	These are the sources from which energy cannot be continuously obtained over a long period of time.

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2.	They are non - conven - tional sources.	They are conventional sources.
3.	These are the natural sources which will never get exhausted.	These are natural sources which would soon depletes.
4.	These sources can be regenerated.	These sources cannot be regenerated.
5.	Examples: Solar energy, and wind energy, hydro-energy, geothermal energy and nuclear energy.	Examples: Coal, petroleum natural gas.

FOUR MARKS QUESTIONS

157. State two advantages and two disadvantages of producing hydro electricity.

Ans :

Advantages of hydro electric energy.
(i) It does not produce any environmental pollution.
(ii) It is renewable source of energy.
(iii) Dam help us in irrigation and they control floods.

Disadvantages :
(i) The flowing water is not available every where.
(ii) The ecological balance in the downstream areas of rivers gets disturbed.

158. What do you mean by degradation of energy ? Explain it by taking two examples of your daily life.

Ans :

Degradation of energy : Energy is transformed from one point to another, the entire energy does not change into desired form of energy but a part of it changes to another form. The part of energy which is converted undesirable or non-useful form is called dissipation of energy. Then the energy is being degraded because this part of energy is not available to us for useful work.

Example :
(i) When we light a bulb only 25% of the electrical energy converts into light energy. The remaining part changes to heat energy.
(ii) When we run a vehicle, only a part of energy obtained from its fuel is used up in running the vehicle, major part is used up in heating the moving parts of the machine.

159. What is a solar cell ? State two uses of solar cells. State whether a solar cell produces a.c. or d.c. Give one disadvantage of using a solar cell.

Ans :

Solar cell : The device which converts solar energy directly into the electricity is called a solar cell.

The solar cells are usually made from semiconductors like silicon and gallium. Due to potential difference a current flows in the circuit connected between the surfaces of semiconductor. A single solar cell of area 4 cm2 produce a potential difference of nearly 0.4 volt to 0.5 volt due to which a current of 60 milliampere can flow. To increase the efficiency a solar panel is made.
A solar cell produces d.c
Two uses of solar cells :
(i) They do not require any maintenance.
(ii) They last over a long period of time.
(iii) Their running cost is almost zero.

160. What is wind energy ? How is wind energy used to produce electricity ? How much electric power is generated in India using the wind energy ?

Ans :

Wind energy : Wind means the large masses of moving air. Due to its motion, has kinetic energy. The kinetic energy of the moving large masses of air is called the wind energy.

Wind energy is used in wind generator to produce electricity by making use of windmill to drive a wind generator. A wind generator is placed at the top of a pillar. The armature of the dynamo is connected to the shaft attached with blades of a wind mill. When wind blows, the blades move and produce kinetic energy, it rotates the blades of turbine and in turn rotates dynamo and generate electricity.

NODIA

161. Draw a simple diagram showing the energy flow in a food chain.

Ans :

Energy flow in food chain :

waves is called the oceanic waves energy.

(iii) **Geo-thermal energy :** The heat energy possessed by rocks inside the earth is called geo thermal energy.

143. State two advantages and two limitations of producing electricity from solar energy ?

Ans :

Advantages of producing electricity from solar energy are as follows :

(i) They do not require any maintenance.
(ii) They last over a long period of time.
(iii) Their running cost is almost zero.
(iv) They do not cause any pollution.

Disadvantages of producing electricity from solar energy are as follows :

(i) This energy cannot be used at night.
(ii) This cannot be used where solar rays are less in power.
(iii) Solar energy produces only D.C. electricity which cannot be used for household purposes.

144. Distinguish between heat and temperature.

Ans :

The difference between heat and temperature are as follows :

	Heat	**Temperature**
1.	Heat is a form of energy which flows.	Temperature is a quantity which tells the thermal state of body.
2.	Its S.I. unit is joule or J.	Its S.I. unit is Kelvin or K.
3.	(It flows from hot body to cold body.	It determines the direction of flow of heat when two bodies at different temp. are placed in contact.

145. State two ways to minimise the impact of global warming.

Ans :

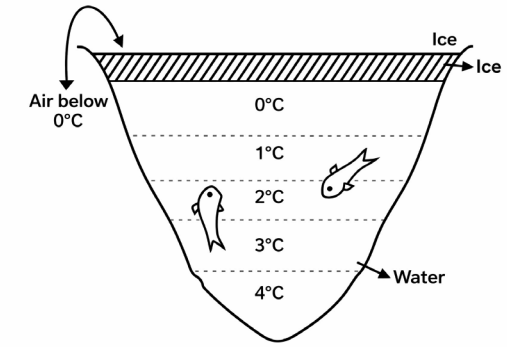
With increasing economic growth and population, energy consumption is increasing and hence this leads to global warming. To minimise global warming following three measures should be taken.

(i) Internal combustion engines in vehicles should be replaced by electric battery vehicles to reduce carbon dioxide emission.
(ii) Reforestation and sustainable use of land should be encouraged. Forest habitats should be maintained.
(iii) Controlling population, through family planing, welfare, reform and the empowerment of women. This will help in reducing population, then consumption for energy and hence will reduce global warming.

146. Draw a diagram showing the temperature of various layers of water in an ice covered pond.

Ans :

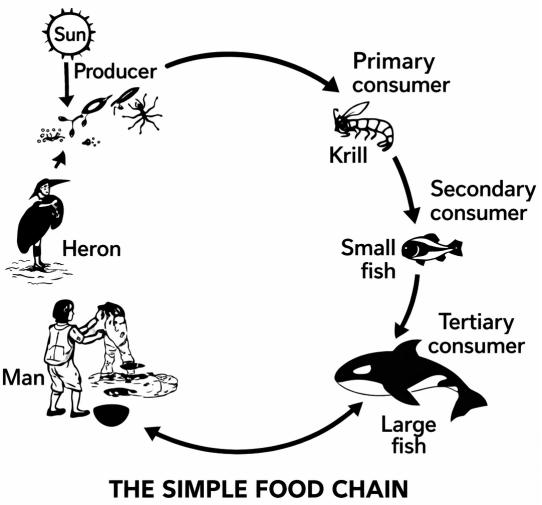
Diagram showing the temperature of the various layers of water in an ice covered pond.



147. Draw a simple diagram showing a food chain.

Ans :

A simple food chain :



THE SIMPLE FOOD CHAIN

148. Name the three kinds of thermal expansion. Out of solids, liquids and gases, which expands more?

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reduce carbon emissions by capturing carbon dioxide from industrial processes and storing it underground. This technology is still in the early stages of development but has the potential to be a significant contributor to reducing greenhouse gas emissions.

4. **Afforestation :** Planting trees and expanding forested areas can help reduce carbon dioxide levels by absorbing carbon dioxide from the atmosphere through photosynthesis. Afforestation can be used in combination with other measures such as renewable energy and energy efficiency to achieve carbon neutrality.
5. **Electric vehicles :** The use of electric vehicles can reduce greenhouse gas emissions from transportation. Governments can incentive the use of electric vehicles through subsidies, tax credits, and other policies.
6. **Sustainable agriculture :** The adoption of sustainable agriculture practices, such as reducing tillage and using cover crops, can help reduce greenhouse gas emissions from the agricultural sector. Sustainable agriculture can also improve soil health and biodiversity.

165. What policy measures should the government enforce in order to minimise global warming?

Ans :

Governments can implement a range of policy measures to minimize global warming. Some of the policy measures that governments can enforce include:

1. **Carbon pricing :** Carbon pricing is a policy that places a price on carbon emissions. This can be done through a carbon tax or a cap-and-trade system. Carbon pricing can incentive individuals and businesses to reduce their carbon emissions by making it more expensive to emit carbon.
2. **Land-use policies :** Governments can implement policies that promote sustainable land use practices such as afforestation, reforestation, and conservation of natural ecosystems. This can help reduce carbon emissions by absorbing and storing carbon in vegetation and soil.
3. **Climate adaptation policies :** Governments can implement policies that help communities adapt to the impacts of global warming, such as sea level rise, increased frequency of extreme weather events, and changes in precipitation patterns.
4. **Energy efficiency standards :** Governments can enforce energy efficiency standards for buildings, appliances, and industrial processes. This can help reduce energy consumption and carbon emissions.

166. Explain the following :

(a) Water pipes in colder countries often burst in winter.
(b) In winter water tank (or ocean) starts freezing from the surface and not from the bottom.
(c) Fishes survive in ponds even when the atmospheric temperature is well below 0°C.
(d) A hollow glass sphere which floats with its entire volume submerged in water at 4°C, sinks when water is heated above 4°C.
(e) A glass bottle completely filled with water and tightly closed at room temperature, is likely to burst when kept in the freezer of a refrigerator.

Ans :

(a) Water pipes in colder countries often burst in winter because of the anomalous expansion of water. As the temperature falls below 4°C to 0°C water expands and exerts large pressure on pipes and they burst.
(b) Tank or ocean freezes from the surface and not from the bottom in winter because of the anomalous expansion of water. As the temperature of atmosphere falls below 0°C. The water of the surface of tank or ocean also attains the temperature of atmosphere. When Temperature of water of the surface falls below 4°C, it contracts and becomes denser and therefore sinks to the bottom till all the water reaches 4°C. The further cooling of top layers below 4°C results in the expansion of water and so its density decreases. As a result it remains on the surface. When the temperature further falls below 0°C water changes into ice but water under ice layer remains at 4°C. As ice is poor conductor of heat helps in keeping water below it at 4°C.
(c) Fishes survive in pond even when the atmospheric temperature is below 0°C. It is because of anomalous expansion of water.
When the temperature falls below 0°C water changes into ice and rises to the top and ice being poor conductor of heat helps to keep water below it at 4°C and fish can live in pond water.
(d) When water is heated, its density decreases and hence hollow glass sphere sinks.
(e) A glass bottle completely filled with water and closed tightly is likely to burst in the freezer of refrigerator because water changes

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128. Show that the energy flow in an ecosystem is linear.

Ans :

The energy flow in ecosystem is from Sun to producers. Producers to primary consumers. Then primary consumers to secondary consumers. Secondary consumers to tertiary consumers and so on is unidirectional and thus linear and it can be well understood in the form of a food chain.

129. What percentage of total electrical power generated in India is obtained from nuclear power plants ? Name two places in India where electricity is generated from nuclear power plants.

Ans :

At present only 3% of the total electrical power generated in India is obtained from the nuclear power plants.
(i) Kota in Rajasthan.
(ii) Narora in Uttar Pradesh.

130. State two advantages and two disadvantages of using nuclear energy for producing electricity.

Ans :

Advantages :
(i) A very small amount of nuclear fuel can produce a tremendous amount of energy.
(ii) Once the nuclear fuel is loaded into a nuclear power-plant. It continues to release energy for several years.

Disadvantages :
(i) It produces very harmful nuclear radiations.
(ii) It is not a clean fuel.

131. State the functions of decomposers in an ecosystem.

Ans :

Decomposers help in forming nutrient cycle of mineral elements. Plants obtain mineral elements from soil and atmosphere. On decomposition of dead bodies of plants and animals by decomposers, mineral elements are again released into the nutrient food. On re-absorption by plants, these elements again enter into circulation and thus a nutrient cycle is formed.

132. State the law which govern the energy flow in an ecosystem.

Ans :

The entrance, transformation and diffusion of energy in ecosystem are governed by the laws of thermodynamics.
According to the first law of thermodynamics : The energy can be transformed from one form to the other form, it can neither be created nor destroyed.
According to the second law of thermodynamics: During the process of transformation of energy, a part is converted in useful form such as heat.

NODIA

133. Name the radiations which are absorbed by the green house gases.

Ans :

Greenhouse gases, such as carbon dioxide, water vapor, and methane, are able to absorb and re-emit certain wavelengths of electromagnetic radiation that are emitted by the Earth's surface. These wavelengths fall within the infrared range of the electromagnetic spectrum.
In particular, greenhouse gases are able to absorb the long-wave radiation that is emitted by the Earth's surface as a result of its temperature.

134. Select the renewable and non-renewable sources of energy from the following :
(a) Coal
(b) Wood
(c) Water
(d) Diesel
(e) Wind
(f) Oil.

Ans :

Renewable sources :
(b) Wood
(c) Water
(e) Wind
Non-renewable sources :
(a) Coal
(d) Diesel
(f) Oil

THREE MARKS QUESTIONS

135. State four ways for the judicious use of energy.

Ans :

Judicious use of Energy.
(i) Fossil fuels such as coal, petroleum, natural gas should be used only for a limited purpose.
(ii) The wastage of energy should be avoided.

exposed metal water supply pipes in her garden have completely burst open. She recalls her recent science lesson on how matter typically changes its dimensions in response to a drop in thermal conditions. However, she notes that the behavior of the water inside the pipe was completely opposite to how the solid metal pipe reacted to the freezing weather. She decides to write down the scientific reasons for this structural failure.

(a) Name and define the general phenomenon by which the metal pipe changes its shape, area, and volume in response to a change in temperature.

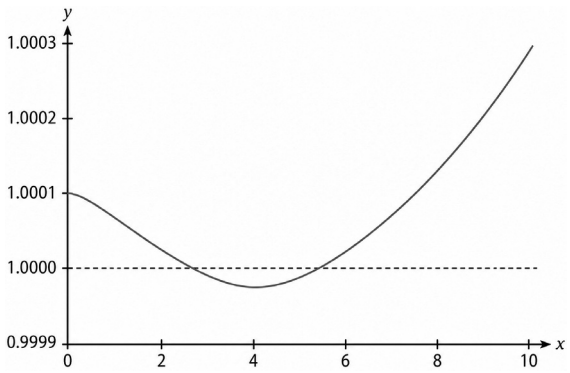
(b) Explain the specific anomalous behavior of water that led to the bursting of the supply pipe.

Ans :

(a) 1. The general phenomenon is called thermal expansion.
2. It is the tendency of matter to change its shape, area, volume, and density in response to a change in temperature.

(b) 1. When atmospheric temperature falls below 4°C, water in the supply pipe expands instead of contracting.
2. If the temperature falls further below 0°C , water freezes into ice, occupies a larger volume, and exerts great pressure on the pipes, causing them to burst.

170. Neha is conducting a series of experiments to track how the physical properties of pure water change as it is gently heated from its freezing point. She records her careful measurements and plots the data on a set of axes. The resulting curve reveals a unique and unusual property of this vital liquid, significantly different from the behavior of other common substances.



(a) Identify the physical quantity plotted on the Y-axis and its corresponding unit based on the standard expansion curve of water shown.

(b) State what happens to the volume of water when it is heated from $0^{\circ}C$ to $4^{\circ}C$.

(c) Define the term 'anomalous expansion of water' and state what happens to the volume of water when heated above $4^{\circ}C$.

Ans :

(a) The physical quantity plotted on the Y-axis is the Volume of 1g of water, and its unit is cm^3.

(b) When water is heated from $0^{\circ}C$ to $4^{\circ}C$, its volume decreases (it contracts).

(c) 1. The expansion of water when it is cooled from $4^{\circ}C$ to $0^{\circ}C$ is called the anomalous expansion of water.
2. On heating further above $4^{\circ}C$, the water starts to expand and its volume increases.

171. Rahul is conducting an experiment in the physics laboratory to study the relationship between different temperature scales. He carefully measures the boiling point of a certain liquid chemical and finds it to be exactly 60°C. His science teacher approaches his lab bench and asks him to express this reading on the Kelvin and Fahrenheit scales for the final lab report. Rahul quickly grabs his notebook and begins applying the conversion formulas he learned in class. During their discussion, his teacher also mentions a theoretical state where all molecular motion of a gas completely ceases. This prompts Rahul to investigate the absolute lower limits of temperature on the Kelvin scale and its equivalent value on the Celsius scale.

(a) Calculate the temperature of the liquid on the Kelvin scale.

(b) Calculate the temperature of the liquid on the Fahrenheit scale.

(c) Name the temperature at which molecular motion of a gas ceases and state its value on the Celsius scale.

Ans :

(a) As we know that ,

$$\mathrm{K} = 273 + \mathrm{t}^{\circ}\mathrm{C}$$

After substituting the value , we get

$$\mathrm{K} = 273 + 60$$
$$= 333\ \mathrm{K}$$

(b)
$$\frac{\mathrm{C}}{5} = \frac{\mathrm{F} - 32}{9}$$
$$\frac{60}{5} = \frac{\mathrm{F} - 32}{9}$$
$$12 = \frac{\mathrm{F} - 32}{9}$$

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(c) Explain how this temperature difference is maintained in the water body, and state one other form of energy that can be obtained from the surface of this water body.

Ans :

(a) Temperature difference = Surface water temperature - Deeper level temperature

Temperature difference = 25°C - 5°C

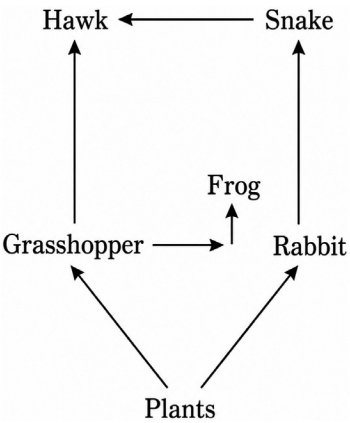
Temperature difference = 20°C

(b) The specific device designed to harness electricity using this temperature difference is known as an ocean thermal energy conversion power plant.

(c) 1. Water at the surface gets heated after absorbing the heat of the Sun, while water at its deeper levels remains at lower temperatures.

2. Another form of energy obtained from the surface due to winds blowing at high speed is called oceanic or sea waves energy.

188. Amit is charting the feeding relationships within a local forest ecosystem. He documents the interactions between various organisms and organises them into an interlocking pattern. The diagram below illustrates the feeding connections he observed among the different organisms in his local forest.



(a) Define the type of interlocking pattern shown in the diagram, and identify the specific trophic level occupied by the grasshopper.

(b) Describe what happens to the amount of energy as it moves upward between the labels, and state which organism forms the base of an energy pyramid.

Ans :

(a) 1. The interlocking pattern of several food chains that do not exist independently in nature is defined as a food web.

2. In this ecosystem pattern, the grasshopper consumes the plants and occupies the trophic level known as the primary consumers.

(b) 1. Energy decreases progressively from one trophic level to another because some energy is wasted as heat or used for respiration.

2. In a pyramid of energy, the producers always form the base with successive levels becoming narrower towards the apex.

189. Sneha is researching renewable energy extraction from the Earth's interior for her science project. She studies a geological cross-section where underground heat is trapped by rock formations. The diagram below illustrates the process used to extract this trapped heat for continuous electricity generation on the surface.

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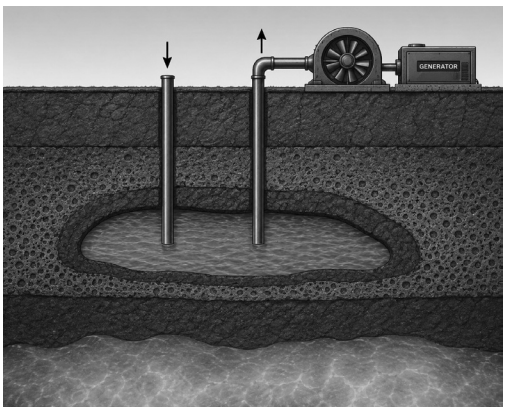

(a) Name the specific regions where the lowest glowing mass heats the underground liquid, and identify the state of the fluid emerging from the second vertical shaft.

(b) Describe the continuous thermal conduction process occurring inside the planet that gives rise to the energy source shown in the diagram.

Ans :

(a) 1. The specific regions below the surface of the earth where the rocks heat the underground water are called hot spots.

2. The heated underground water gets compressed at high pressure between the rocks and emerges from the shaft as steam.

(b) 1. The continuous conduction of thermal energy in the form of heat occurs from the hot core to the surface of the planet.

2. This distinct difference in temperature between the deep core of the planet and

(b) State the condition that determines the direction of heat flow when two bodies are kept in contact, based on the analogy shown.
(c) Describe how the total internal energy of a hot body and a cold body changes when they are kept in contact until they reach thermal equilibrium.

Ans :

(a) The physical quantity analogous to the water level is temperature.
(b) The direction of heat flow is determined by temperature; heat always flows from a hotter body (at a higher temperature) to a colder body (at a lower temperature).
(c) 1. The internal energy of the hot body decreases as it transfers energy.
2. The internal energy of the cold body increases as it gains energy until their temperatures are equal.

175. Rohit is conducting a laboratory demonstration to compare the heating effects on solids, liquids, and gases. He carefully heats a solid iron rod, a glass beaker filled with oil, and a tightly sealed balloon filled with atmospheric air. He observes that all three states of matter expand upon heating, but they do so in entirely different ways and at vastly different rates. He notes that the solid iron rod expands primarily along its length, which he can measure with a scale. Meanwhile, the oil and the trapped air expand differently because they completely lack a fixed shape. He also measures the density changes in each material as their volumes increase under continuous heating.
(a) Name the type of expansion that occurs when there is an increase in the length of a solid.
(b) State the type of expansion exhibited by liquids and gases, and give a reason why they only show this type.
(c) Compare the rate of expansion of liquids and gases with that of solids when subjected to an equal increase in temperature.
(d) State what generally happens to the density of a substance when it is heated.

Ans :

(a) The increase in length is called linear expansion.
(b) Liquids and gases exhibit only cubical (or volume) expansion because they do not have a definite shape.
(c) The volume of liquids and gases increases more with an increase in temperature as compared to an increase in solids.
(d) On heating a substance, its volume increases but its mass remains the same, so its density generally decreases.

176. Kavita is a keen biology student studying the devastating effects of extreme cold weather on plant cellular structures. She learns from her textbook that during severe winters, some delicate plants completely wither and die because the liquid flowing within their structures freezes solid. She decides to correlate this biological phenomenon with her physical science notes on the unusual thermal behavior of water between very specific temperature ranges. She realizes that the essential liquid inside the plant reacts to the dropping temperatures exactly like the water in domestic pipelines. This unique expansion leads to catastrophic structural damage within the tiny tubes of the plant's stem. She drafts an essay explaining this cross-disciplinary concept.
(a) Name the specific temperature range in which water shows unusual expansion instead of contraction upon cooling.
(b) State the exact temperature at which water has maximum density.
(c) State what happens to the water in the capillaries of plants during cold weather that causes the capillaries to burst.
(d) State the final consequence on the plant after its capillaries burst.

Ans :

(a) The unusual expansion occurs when water is cooled in the temperature range from $4^{\circ}C$ to $0^{\circ}C$.
(b) The density of water is maximum at $4^{\circ}C$.
(c) The water in the capillaries freezes into ice and expands, exerting pressure on the wall of the capillaries and making them burst.
(d) As a result of the capillaries bursting, the plant gets deprived of water and eventually dies.

177. Manoj is setting up an important classical demonstration in the physics lab to prove how water behaves differently from other liquids as it cools. He carefully fills the central container with water at room temperature and packs the surrounding jacket with a special cooling mixture. He then meticulously records the readings of the two measurement devices over a period of time to track the cooling process at different depths.

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CHAPTER 7

Reflection of Light

SUMMARY

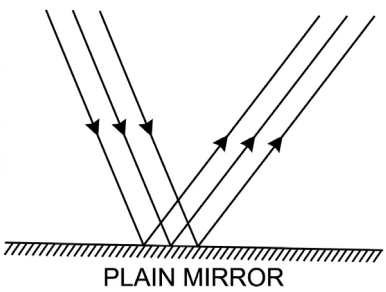
1. REFLECTION OF LIGHT AT A PLANE SURFACE

The return of light into the same medium after striking a surface is called reflection. We see the objects around us due to reflection. A plane mirror reflects almost all the light falling on it.

1.1 Kinds of Reflection

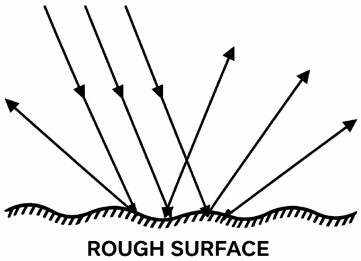
There are two kinds of reflection regular-reflection and irregular reflection.

1. Regular Reflection : When a beam of light falls on a smooth and polished surface (a plane mirror), regular reflection occurs.



The incident rays and reflected rays are parallel beams.

2. Irregular Reflection : When a beam of light falls on a rough surface (a wall or a road), irregular reflection occurs.



The incident rays are parallel beams, but the light reflected from different surfaces will reflect at different angles obeying the laws of reflection.

1.2 Terms Related to Reflection

The terms related to the reflection

1. Incident ray : The light ray striking a reflecting surface is called the incident ray.
2. Point of incidence : The point at which the incident ray strikes the reflecting surface is called the point of incidence.
3. Reflected ray : The light ray obtained after reflection from the surface in the same medium as the incident ray is called the reflected ray.
4. Normal : The perpendicular drawn to the surface at the point of incidence is the normal.
5. Angle of incidence : The angle made by the incident ray with the normal at the point of incidence is called the angle of incidence.
6. Plane of incidence : The plane containing the incident ray and the normal is called the plane of incidence.
7. Angle of reflection : The angle made by the reflected ray with the normal at the point of incidence is called the angle of incidence.
8. Plane of reflection : The plane containing the reflected ray and the normal is called the plane of incidence.

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1.3 Laws of Reflection

Reflection at a surface obeys two laws of reflection:

(a) First law of reflection : The incident ray, the normal to the surface at the point of incidence and the reflected ray, all lie in the same plane.

(b) Second law of reflection : The angle of incidence is equal to the angle of reflection.

2. FORMATION OF IMAGE BY REFLECTION

There are two types of images. real and virtual images.

(a) Real image : It is the image which can be obtained on a screen. It is the image formed when light rays actually intersect after reflection. It is an inverted image.

(b) State the value of the maximum density of water as shown by the peak of the graph.
(c) State what happens to the density of water when the temperature increases from 4°C to 10°C.
(d) Give the reason why the density of water increases when the temperature rises from 0°C to 4°C.

Ans :

(a) The physical quantity plotted is Density, and its unit is $g\,cm^{-3}$.
(b) The maximum density of water is $1.000\ g\,cm^{-3}$ at 4°C.
(c) The density of water decreases when the temperature increases from 4°C to 10°C.
(d) Between 0°C and 4°C, water contracts on heating, causing its volume to decrease while its mass remains constant, resulting in an increase in density.

180. Meera investigates a single photovoltaic device in her school physics laboratory. She measures its surface area as 4 cm^2 and tests its electrical output under direct sunlight. She connects it to a small measuring circuit and records the steady voltage and current readings. She then covers the device completely and observes that the current immediately drops to zero. She aims to calculate the exact electrical output knowing that such devices convert a specific percentage of light energy into electricity.
(a) State the typical voltage range and the specific small current generated by this single device.
(b) Calculate the electrical energy output if 200 J of light energy falls directly on the device, using its standard energy conversion efficiency.
(c) Name the two specific impurities added in small quantities to the semiconductor layers of this device.

Ans :

(a) The typical voltage range is 0.5 volts to 0.6 volts, and the small current generated by the single solar cell is 60 milliampere.
(b) Electrical energy output = Conversion efficiency percentage × Incident light energy

$$\text{Electrical energy} = \frac{25}{100} \times 200\ \text{J}$$

$$\text{Electrical energy} = 50\ \text{J}$$

(c) The two specific impurities added in small quantities to the semiconductor silicon layers to create a potential difference are boron and arsenic.

181. Rahul was studying a grassland ecosystem for his environmental science project. He recorded that exactly 5,000,000 J of solar energy was incident on a specific patch of grass during his observation period. He noted that the plants synthesised food, and these plants were later consumed by grasshoppers. The grasshoppers were eventually eaten by frogs residing in the same habitat. Rahul wanted to determine the exact amount of energy transferred at each step of this feeding process.
(a) Calculate the solar energy utilised by the grass during the process of photosynthesis.
(b) State the specific law that governs the amount of energy transferred from the grass to the grasshopper.
(c) Calculate the energy available to the frog if the grasshopper consumes the grass. Give one reason why the available energy decreases as it moves to the frog.

Ans :

(a) Energy utilised = 1% of incident solar energy

$$\text{Energy utilised} = \left(\frac{1}{100}\right) \times 5{,}000{,}000\ \text{J}$$

$$\text{Energy utilised} = 50{,}000\ \text{J}$$

(b) The Ten Percent Law formulated by Raymond Lindeman governs the amount of energy that gets transferred to the successive trophic levels in a food chain.
(c) Herbivore energy = 10% of producer energy; Carnivore energy = 10% of herbivore energy

$$\text{Grasshopper energy} = \left(\frac{10}{100}\right) \times 50{,}000\ \text{J}$$

$$= 5{,}000\ \text{J}.$$

$$\text{Frog energy} = \left(\frac{10}{100}\right) \times 5{,}000\ \text{J}.$$

$$\text{Energy available to frog} = 500\ \text{J}$$

A major portion of energy is utilised by the organism for respiration and tissue building, while the underutilised portion is released to the surroundings as heat.

182. Varun is analyzing the results of an experiment demonstrating the unusual thermal behavior of water. He looks at two cooling curves generated simultaneously from two different thermal sensors placed at the top and bottom of a specially designed cylindrical apparatus. The graphs show how the thermal state at different depths of the water column changes over time as a central freezing mixture is applied.

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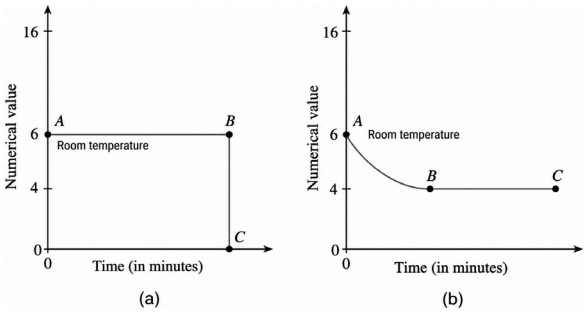


(a) Identify which thermometer's reading is represented by graph (a) where the final temperature reaches 0°C.

(b) Identify which thermometer's reading is represented by graph (b) where the final temperature becomes steady at 4°C.

(c) State what the horizontal portion AB in graph (a) indicates about the temperature in the upper portion of the cylinder initially.

(d) Give the reason why the curve drops from B to C in graph (a) to reach 0°C.

Ans :

(a) Graph (a) represents the reading of the upper thermometer T_1.

(b) Graph (b) represents the reading of the lower thermometer T_2.

(c) The portion AB indicates that the temperature in the upper portion remains constant at room temperature initially because the dense cool water sinks downwards.

(d) On cooling below 4°C, the central water expands, its density decreases, and it becomes lighter and rises up, causing the temperature reading to decrease continuously to 0°C.

183. Arjun visits a coastal area in Gujarat to study an alternative energy setup. He measures the continuous air movement over several days, recording an average speed of 30 km per hour. He observes massive three-bladed structures mounted on tall pillars rotating continuously. He notes that the kinetic energy of the moving air is being converted into rotational kinetic energy, which then operates an internal dynamo. He plans to propose a similar setup for his hometown located in a dense, calm valley.

(a) Evaluate if his hometown is suitable for this setup by providing two limitations of this specific energy source.

(b) Describe the two sequential energy transformations occurring from the moving air to the final output generated by the dynamo.

Ans :

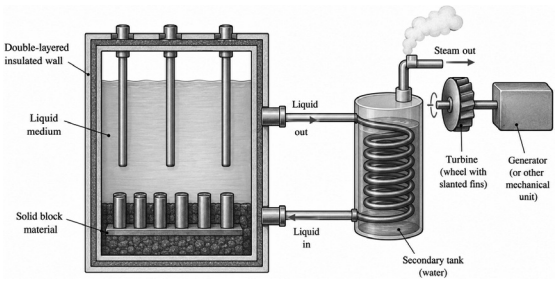
(a) 1. The availability of wind is not constant round the year steadily in a dense valley, making it unsuitable.

2. A large area of land is required for establishing an interconnected wind energy farm.

(b) 1. The kinetic energy of the blowing wind changes into the rotational kinetic energy of the windmill blades upon striking them.

2. The rotation of the blades rotates the armature of the connected dynamo in the magnetic field, generating an alternating current.

184. Priya learns about electricity generation from radioactive substances in her physics class. She examines the technical schematic of a heavy reactor core where controlled chain reactions occur. The diagram below details the internal components used to generate massive amounts of heat for electricity production.



(a) Identify the specific element used to construct the three suspended vertical rods in the central vessel of the diagram.

(b) Name the radioactive substance typically used in the shorter vertical cylinders, and state how its energy output compares to burning one atom of carbon.

(c) Identify the specific material of the densely shaded solid block surrounding the lower cylinders in the diagram.

Ans :

(a) The specific material used to construct the three suspended vertical control rods inside the central vessel of the reactor is cadmium.

(b) 1. The radioactive substance most commonly used as fuel in the shorter vertical cylinders of the nuclear power plant is Uranium-235.

2. The fission of one atom of Uranium-235 produces ten million times more energy than the energy produced by burning one

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atom of carbon.

(c) The densely shaded solid block material surrounding the lower cylinders acts as a moderator, and it is made of graphite.

185. Sanjay assists his uncle in setting up a rural waste management plant. They collect cattle dung, crop residues, and agricultural waste, mixing them with water. This mixture is fed into a sealed underground chamber completely devoid of oxygen. After a few days, Sanjay observes the continuous production of a smokeless combustible gas. He notes that the remaining slurry is extracted to be used in the agricultural fields.

(a) Name the major constituent gas produced in this chamber and state its approximate maximum percentage.

(b) State the specific term for the chemical energy stored in the raw organic materials collected by Sanjay.

(c) Identify the type of micro-organisms responsible for decomposing the organic matter in this specific setup.

(d) State the specific agricultural use of the slurry left behind after extracting the combustible gas.

Ans :

(a) The major constituent gas produced in this anaerobic decomposition process is methane, and it can make up to seventy percent of the total mixture.

(b) The specific term used for the chemical energy stored in the waste and dead parts of living beings like plants and animals is bio-energy.

(c) The micro-organisms responsible for decomposing the organic matter in the underground chamber without oxygen are specifically known as anaerobic microbes.

(d) The organic slurry left after extracting the bio-gas is excellent for agricultural use because it contains vital returned nutrients like nitrogen and phosphorus.

186. Ritu studies the properties of domestic cooking fuels in her kitchen. She examines a heavy red cylinder and reads its safety manual. The manual states that the cylinder contains a highly flammable mixture of hydrocarbon gases compressed into an 86% liquid state. Ritu intentionally opens the valve slightly without igniting it and immediately detects a strong, foul odour. She quickly closes the valve to prevent any hazards.

(a) Name the two specific hydrocarbon gases that primarily make up the fuel compressed inside this cylinder.

(b) Name the specific odorant chemical added to this fuel so that leaks can be detected easily.

(c) State the exact chemical formula of the odorant chemical added to this liquid fuel.

(d) Classify this cooking fuel as either a renewable or non-renewable source of energy.

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Ans :

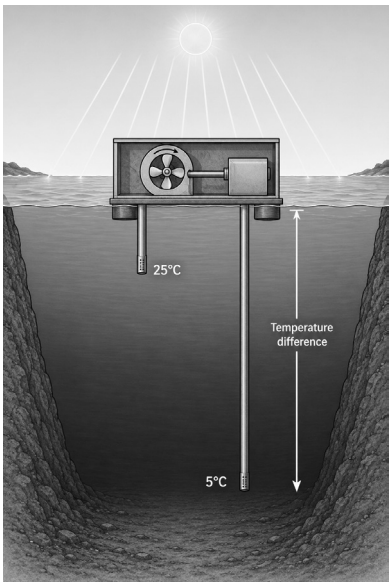
(a) The two specific highly flammable hydrocarbon gases that primarily constitute the liquid petroleum fuel inside the cylinder are propane and butane.

(b) The powerful odorant chemical added to the cylinder so that highly flammable gas leaks can be detected easily is called ethanethiol.

(c) The exact chemical formula of the powerful odorant ethanethiol added to the liquid petroleum gas cylinder to detect leaks is C_2H_5SH.

(d) This cooking fuel is classified as a non-renewable or conventional source of energy because it will get exhausted and cannot be replenished quickly.

187. Rohan researches alternative energy technologies for coastal regions. He studies a specific power plant that harnesses the thermal conditions of ocean waters. He observes the diagram below illustrating the internal working principle of this industrial power plant structure.



(a) Calculate the exact temperature difference between the surface water and the deeper water based on the provided diagram.

(b) Name the specific power plant designed to harness electricity using the temperature difference shown in the diagram.

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$$108 = F - 32$$

$$F = 140^{\circ}F$$

(c) The temperature is known as absolute zero. Its value on the Celsius scale is $-273^{\circ}C$.

172. Meera is assigned a school project to investigate the thermal properties of different materials under extreme heat. She places a large iron block and a small iron nail inside the same laboratory oven. She waits patiently until they both reach a uniform thermal state of $150^{\circ}C$. When she removes them using tongs, she carefully drops each item into two separate, identical beakers filled with cold water. She immediately observes that the water containing the large iron block becomes much hotter than the water with the small iron nail. She realizes that even though both objects shared a specific thermal metric inside the oven, they possessed vastly different amounts of total thermal energy.

(a) State the physical quantity that is the same for both the iron block and the nail when inside the oven, and define it.

(b) Give one reason why the large iron block transfers more heat to the water than the small iron nail despite being in the same thermal state.

(c) State two other differences between heat and temperature based on their nature (cause or effect) and their SI units.

Ans :

(a) The physical quantity is temperature. It is that quantity which tells about the thermal state of a body and determines the direction of the heat flow.

(b) The quantity of heat contained in a body depends on its mass; since the large iron block has more mass, it contains more heat energy.

(c) 1. Heat is the cause, whereas temperature is the effect.

2. The SI unit of heat is the joule (J), whereas the SI unit of temperature is the kelvin (K).

173. Arjun is studying the direct conversion of mechanical work into thermal energy using a standard bicycle pump. He rapidly pumps air into the bicycle tube for several minutes and notices that the metallic barrel of the pump gets significantly heated. He recalls his physics teacher explaining that every substance is made up of randomly moving molecules that possess specific types of energy. He reads his textbook to understand how these molecular movements contribute to the total energy of the object. He then estimates the total thermal energy generated in the barrel to be 1.5 kcal. Arjun now wants to convert this value into the standard SI unit of energy to complete his practical calculations.

(a) Explain how the internal energy of a body is related to the kinetic and potential energy of its molecules.

(b) Calculate the heat energy generated in the pump barrel in joules, given that $1\,\text{cal} \approx 4.2\,\text{J}$

Ans :

(a) 1. Molecules possess vibrational kinetic energy due to their random motion and possess potential energy because they exert a force of attraction on each other.

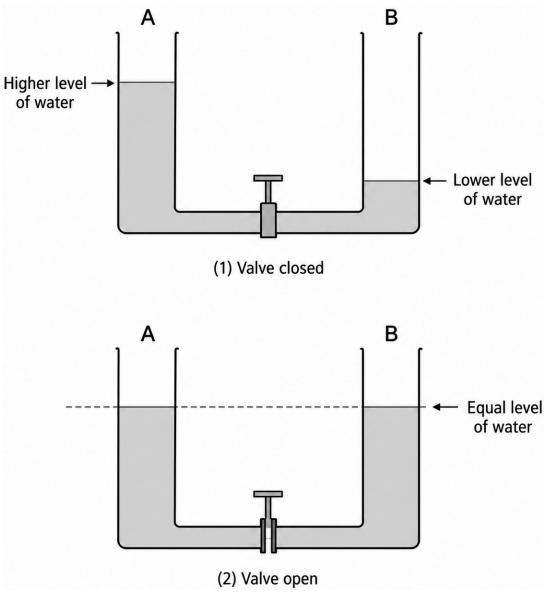
2. The sum of the kinetic energy and potential energy of all these molecules is called the internal energy of a body.

(b) $1\,\text{kcal} = 1000\,\text{cal}$

$= 1.5 \times 1000 = 1500\,\text{cal}$

$= 1500 \times 4.2\,\text{J} = 6300\,\text{J}$

174. Deepak is studying the concept of heat transfer between bodies at different thermal states. To help him understand, his teacher sets up a simple hydrodynamic model to demonstrate how the direction of flow depends on a specific level rather than the total amount of contents. He observes the flow of the liquid in the apparatus when the central mechanism is operated.



(a) Identify the physical quantity in thermal physics that is analogous to the water level in the given diagram.

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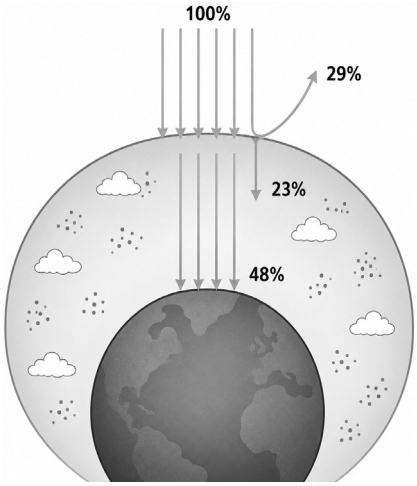
its exterior surface is officially termed as the geothermal gradient.

190. Vikram sets up a flat solar data collector on his school rooftop. He measures the incoming solar radiation on a perfectly square area of 1 m^2 at the upper atmosphere. The diagram below represents the distribution of solar radiation striking the Earth's atmosphere and subsequently reaching the solid surface.

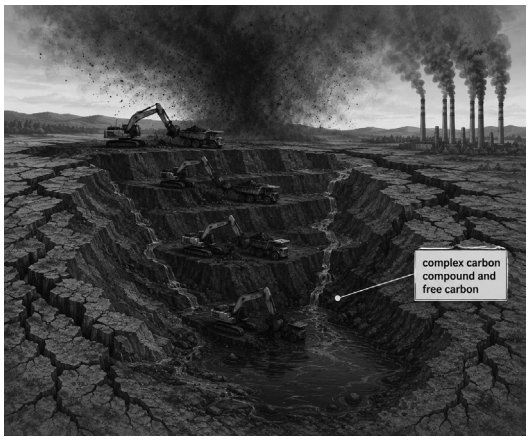


(a) State the average estimated value of solar energy reaching m^2 area of the upper atmosphere per second, based on the chapter.
(b) Identify the two main types of rays that constitute the radiation penetrating the atmosphere and reaching the solid surface in the diagram.
(c) State the specific natural phenomena caused by the forty-eight percent of energy absorbed by the solid surface and water bodies.
(d) State one limitation related to the initial setup cost of creating interconnected arrays to mathematically harness this incident radiation.

Ans :

(a) The average solar energy reaching the upper atmosphere of the earth per second on an area of one square metre is nearly 1.34 kW m^{-2}.
(b) The radiation that penetrates the atmosphere and reaches the solid surface of the Earth consists mainly of visible light and infrared heat rays.
(c) The total incoming solar energy absorbed by land and water bodies causes natural phenomena like winds, storms, rains and snowfall.
(d) The initial cost of setting up is high because special grade silicon and silver wire used to interconnect the cells are very expensive.

191. Karan visits an open-pit mining site in Jharkhand. He observes heavy machinery extracting a dark, naturally occurring solid from deep beneath the surface. The diagram below illustrates the extraction process occurring at this site, the chemical nature of the material, and the visible environmental impact.



(a) Identify the specific solid fossil fuel being extracted from the deep mines based on the chemical composition mentioned in the text box.
(b) Name the specific gas released in substantial amounts into the atmosphere during the mining process of this solid fuel.
(c) Name the major environmental pollutant gas produced when this extracted solid fuel is burned in electric power plants.
(d) Name the four main types in which this solid fossil fuel is predominantly found in nature.

Ans :

(a) The naturally occurring combustible solid fossil fuel made up of complex carbon compounds extracted from the deep mines is coal.
(b) Mining this solid fuel deeply disturbs the land and chemistry of rainwater runoff while releasing a substantial amount of methane gas.
(c) Burning this extracted solid fossil fuel in electric power plants is a major source of the environmental pollutant carbon dioxide.
(d) This naturally occurring solid fuel extracted from mines is predominantly found in four main types classified as anthracite, bituminous, subbituminous, and lignite.

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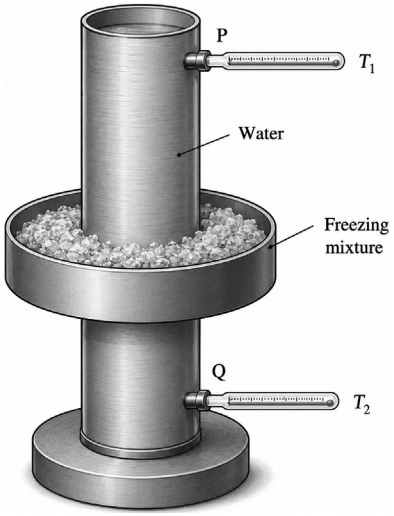
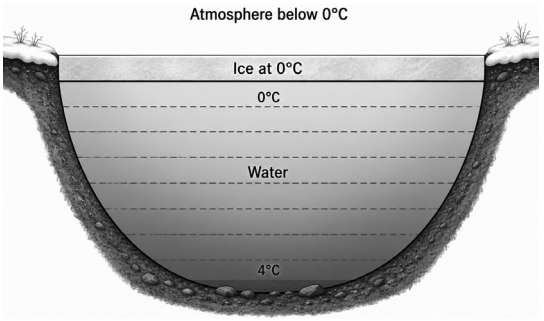


(a) Identify the specific freezing mixture placed in the cylindrical trough and state the initial temperature readings of thermometers T_1 and T_2 at the very start of the experiment.
(b) Explain the reason why the reading of the lower thermometer T_2 decreases rapidly first and becomes steady at $4^{\circ}C$.

Ans :

(a) 1. The freezing mixture consists of ice and salt.
2. At the start of the experiment, both thermometers T_1 and T_2 show the same temperature, which is the room temperature.
(b) 1. As the freezing mixture cools the water in the central portion, the water contracts, its density increases, and it sinks to the bottom.
2. Warm water from the bottom rises up; this convection cools the lower part rapidly until the entire water below the central part reaches $4^{\circ}C$.

178. Priya is reading an article about the survival of aquatic ecosystems in extremely cold climates. The article includes an illustration of a water body during a severe winter, showing how different thermal layers form. She realizes that the peculiar behavior of this liquid ensures that the entire habitat does not freeze solid from the bottom up, allowing fish to survive.

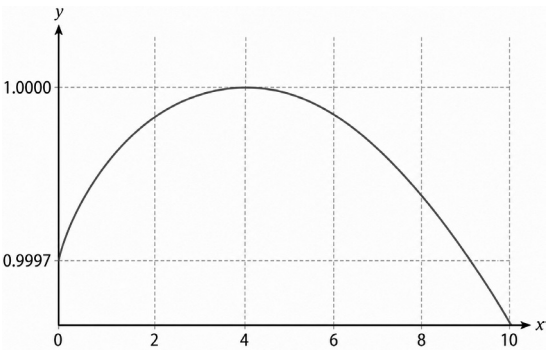


(a) State the reason why the ice layer forms at the top surface rather than at the bottom of the pond.
(b) Explain how the layer of ice helps in the preservation of aquatic animals in the deep water below.

Ans :

(a) 1. When water on the surface cools below $4^{\circ}C$ to $0^{\circ}C$, it expands and its density decreases.
2. Since the density of ice is less than that of water, it does not sink to the bottom but remains floating on the top surface.
(b) 1. Ice is a poor conductor of heat and acts as an insulating layer over the pond.
2. It does not allow heat from the warmer water at the bottom to flow out to the freezing atmosphere, thereby keeping aquatic animals alive.

179. Anjali is studying the thermal characteristics of liquids for her science fair project. She carefully measures the mass and volume of a specific liquid sample at various temperatures and calculates its mass per unit volume. She plots these calculated values against the temperature and obtains a curved graph that highlights a critical point of maximum concentration at a specific thermal mark.



(a) Identify the specific physical quantity plotted on the Y-axis and state its unit.

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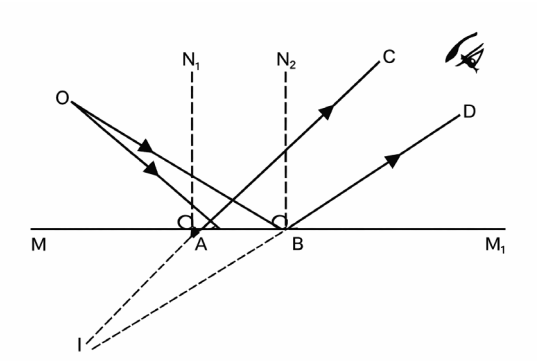
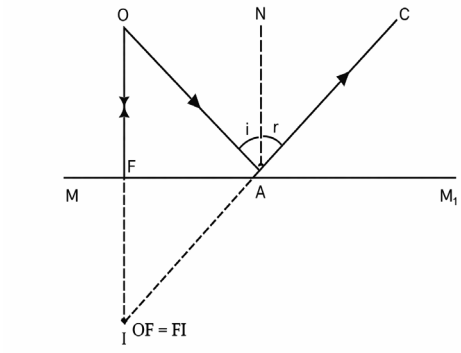
(b) Virtual image : It cannot be obtained on a screen. It is the image formed when light rays do not actually intersect after reflection but appear to diverge from the image. The light rays intersect geometrically when they are produced backwards. It is an erect image.

2.1 Image of a Point Object Formed by a Plane Mirror

1. OA and OB are the two rays from object 0 incident on a plane mirror MM'. They get reflected from the mirror by obeying the laws of reflection. AC and BD are the reflected rays.



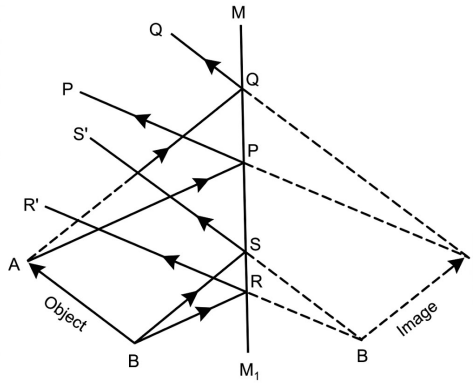
2. The image I is formed behind the mirror and is located by producing AC and BD backwards. This image is a virtual image because the reflected rays do not intersect actually.
3. Position of Image : The image I is as far behind the mirror as the object O is in front of it.



4. Thus, the image is as far behind the mirror as the object is in front of it, that is, the perpendicular distance of the image from the mirror is equal to the perpendicular distance from the object.

2.2 Image of an Extended Object Formed by a Plane Mirror

1. An object AB is placed in front of a mirror MM'. Light rays travel from all points of the object in all directions.
2. A' is the virtual image of point A, and B' is the virtual image of point B.
3. In a similar way, all the points on object AB form virtual images on the mirror between A and B, giving rise to the virtual image A' B' of AB.



4. This image is erect and of the same size as the object. The perpendicular distance of each point behind the mirror is equal to the corresponding point of the object in front of the mirror.

2.3 Lateral Inversion

The interchange of left and right sides in the image of an object in a plane mirror is called lateral inversion.

1. Any symmetrical letter will appear as is after lateral inversion. Examples: A, H, I, M, 0, T, U, V, W and X.
2. The word 'AMBULANCE' is written as 'HOZAJUEIMA' on ambulances. If a car driver is driving in front of the ambulance, then the image on the rear view mirror will appear normal to him, and he can give way to the ambulance.

2.4 Characteristics of the Image Formed by the Plane Mirror

1. The characteristics of the image formed by a plane mirror are
2. The image formed by a plane mirror is always virtual and erect.
3. The size of the image is equal to the size of the object, and the image is laterally inverted.
4. The image formed by the plane mirror is as far behind the mirror as the object is in front of it.

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11. In the experimental verification of the laws of reflection using a flat drawing board and pins, what does the placement of all four pins on the exact same sheet of paper physically verify?
(A) The angle of incidence equals the angle of reflection.
(B) The incident ray, reflected ray, and normal lie in the same plane.
(C) The virtual image is formed at the same distance behind the mirror.
(D) The final image formed is always completely laterally inverted.

Ans : (B)

Placing the paper on a completely flat board ensures that the lower tips of all object pins and image pins exist on a single uniform plane. This simple experimental arrangement physically verifies the first fundamental law of optical reflection.

12. Why is the word AMBULANCE specifically written as laterally inverted on the very front surface of the medical vehicle?
(A) So that street pedestrians can read it without any visual glare.
(B) Because all plane mirrors naturally invert images in a vertical direction.
(C) So that drivers ahead see the upright word in their rear-view mirrors.
(D) To completely avoid irregular diffused reflection from the metallic vehicle's surface.

Ans : (C)

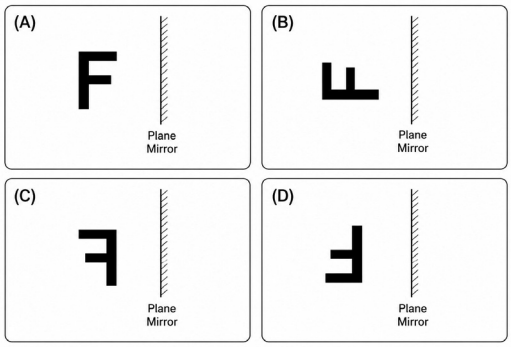
Plane mirrors typically produce completely laterally inverted images where the left side vividly appears on the right. Writing the important word in reverse cleverly allows the rear-view mirror of any preceding vehicle to reinvert it, making text perfectly legible.

13. Which of the following specific sets of English letters does NOT show any noticeable lateral inversion when viewed in a plane mirror?
(A) P, R, S, Z
(B) A, H, I, M
(C) B, C, D, E
(D) F, G, J, K

Ans : (B)

Lateral inversion is completely unnoticeable in specific alphabet letters because they fundamentally possess complete bilateral symmetry around a central vertical axis. Letters like A, H, I, and M visually look exactly identical when their left and right sides interchange.

14. Which option correctly represents the laterally inverted image of the letter 'F' when viewed in a plane mirror?



(A) The letter 'F' unchanged.
(B) The letter 'F' flipped horizontally (a correct laterally inverted image).
(C) The letter 'F' flipped vertically (upside down).
(D) The letter 'F' rotated 90 degrees clockwise.
(A) F
(B) Ⅎ
(C) Ⅎ (upside down)
(D) ⅃

Ans : (B)

Explanation: Lateral inversion is the interchange of the left and right sides in the image formed by a plane mirror. The top and bottom parts remain unchanged. When the letter 'F' is viewed in a mirror, its left side appears as the right side and vice versa, resulting in the horizontally flipped version shown in option (B).

15. Consider the formation of an optical image of a point object by a standard plane mirror.
I. The image is formed behind the mirror surface.
II. The reflected rays actually meet in space to form the image.
III. The perpendicular distance of the image equals the perpendicular object distance.
IV. The resulting image is strictly virtual in nature.
Which of the given statements are correct?
(A) I, II, and III
(B) I, II, and IV
(C) I, III, and IV
(D) II, III, and IV

Ans : (C)

Reflected rays from a flat plane mirror naturally diverge and never actually intersect in open space. Instead, they strictly appear to meet when

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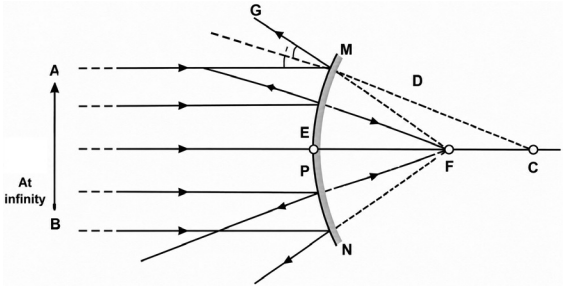
2. The point from which a number of parallel rays appear to emerge after reflecting from the mirror is called the principal focus of a convex mirror. It is also represented by F.

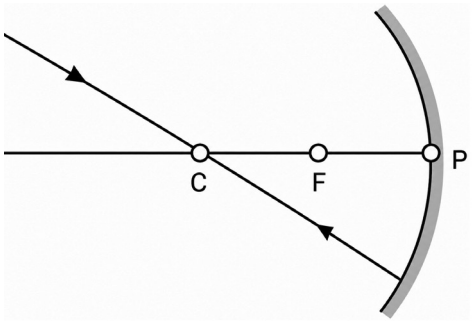


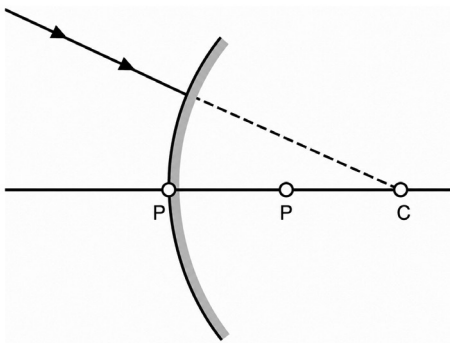
3. The distance between the pole and the focus of the mirror is known as the focal length of the mirror. It is denoted as *f*.
4. For spherical mirrors of small aperture, R = 2f.

5. CONSTRUCTION OF IMAGE: RAY DIAGRAM

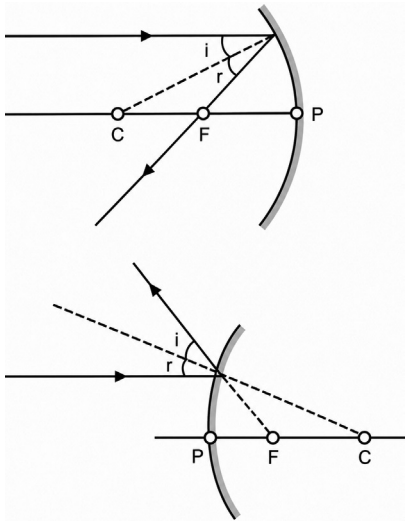
There are certain rules to draw a ray diagram to locate the image formed by a spherical mirror.

1. First rule: A ray of light passing through the centre of curvature of a concave mirror or a ray directed in the direction of the centre of curvature of a convex mirror is reflected along the same path after reflection.

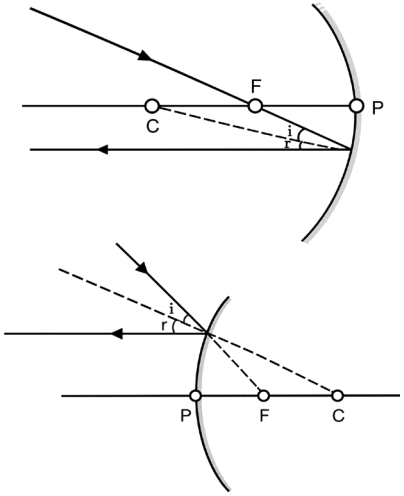




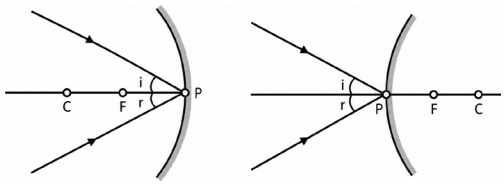
2. Second rule: A ray of light parallel to the principal axis, after reflection, passes through the principal focus in case of a concave mirror or appears to diverge from it in case of a convex mirror.



3. Third rule: A ray passing through the principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror emerges parallel to the principal axis of the mirror after



4. Fourth rule: A ray of light incident obliquely towards the pole of a mirror is reflected obliquely as per the laws of reflection. The angle of incidence is equal to the angle of reflection.



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10. DISTINCTION OF MIRRORS WITHOUT TOUCHING

The mirror is held near the face and the image is seen. Three cases arise from this:
Case (i) : If the image is upright, of the same size as the object and does not change in size by moving the mirror towards or away from the face, then the mirror is a plane mirror.
Case (ii) : If the image is upright, magnified and increases in size by moving the mirror away from the face, then the mirror is a concave mirror.
Case (iii) : If the image is upright, diminished and decreases in size by moving the mirror away from the face, then the mirror is a convex mirror.

OBJECTIVE QUESTIONS

1. What is a group of light rays coming out from a point source and going out in all directions away from each other called?
(A) Parallel beam of light
(B) Convergent beam of light
(C) Divergent beam of light
(D) Reflected beam of light

Ans : (C)

A beam of light consists of a bundle of rays. When these light rays originate from a single point source and spread out in all directions, the collection is known as a divergent beam of light, much like a torch.

2. Consider the following statements regarding different types of beams of light:
I. A parallel beam consists of rays that never intersect.
II. A convergent beam consists of rays that meet at a point.
III. A divergent beam comes from a point source and spreads.
IV. A magnifying glass creates a perfectly divergent beam.
Which of the given statements are correct?
(A) I, II, and III
(B) I, II, and IV
(C) I, III, and IV
(D) II, III, and IV

Ans : (A)

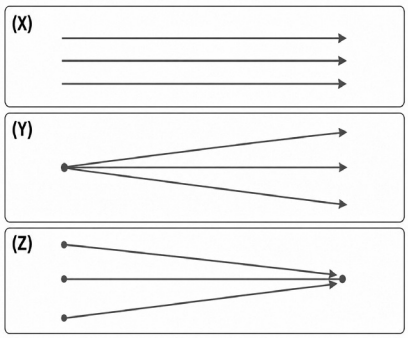
Light rays from the sun are parallel. A magnifying glass brings parallel rays together, forming a convergent beam rather than a divergent one. A divergent beam spreads outward from a source. Thus, the first three statements are perfectly correct.

3. Which of the following objects acts as a non-luminous object in our daily life?
(A) The glowing sun
(B) A burning candle
(C) The shining moon
(D) A hot electric filament

Ans : (C)

Non-luminous objects cannot emit light by themselves and remain visible only when they reflect light from a luminous source. The moon does not produce its own light but shines by reflecting the incident sunlight towards the surface of earth.

4. The diagram below illustrates three different types of light beams.



(A) (X) Divergent, (Y) Convergent, (Z) Parallel
(B) (X) Convergent, (Y) Parallel, (Z) Divergent
(C) (X) Parallel, (Y) Divergent, (Z) Convergent
(D) (X) Parallel, (Y) Convergent, (Z) Divergent

Ans : (C)

A parallel beam consists of light rays that travel parallel to each other. A divergent beam originates from a point source and spreads out. A convergent beam consists of rays that come together to meet at a single point. The diagram correctly depicts (X) as parallel, (Y) as divergent, and (Z) as convergent.

5. What specific material is applied at the back of a silvered glass surface to protect the reflecting layer in a plane mirror?
(A) Copper sulphate solution
(B) Red lead oxide coating
(C) Aluminium oxide layer
(D) Zinc sulphide paint

Ans : (B)

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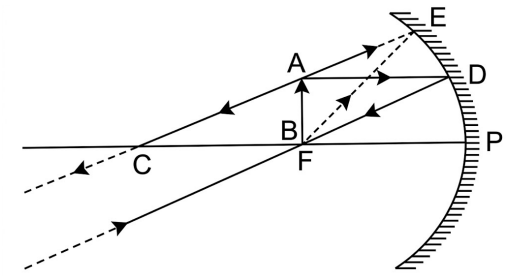
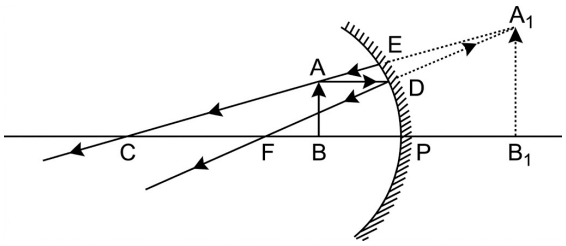


CASE (vi):

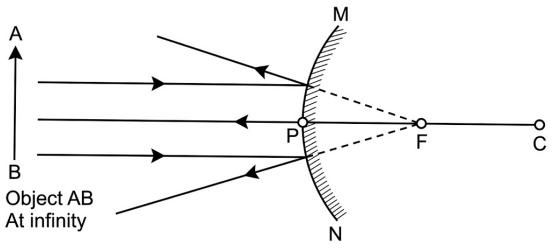
Position of object	Position of image	Size of image	Nature of image
Between P and F	Behind mirror	Magnified	Virtual and erect



7. RAY DIAGRAMS FOR FORMATION OF IMAGES: CONVEX MIRROR

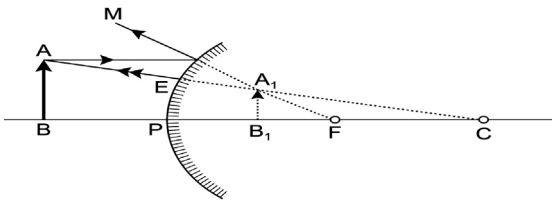
CASE (i):

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F behind the mirror	Highly diminished point-sized	Virtual and erect



CASE (ii):

Position of object	Position of image	Size of image	Nature of image
Between infinity and the pole of the mirror	Between P and F behind the mirror	Diminished	Virtual and erect



8. USES OF CONCAVE MIRROR

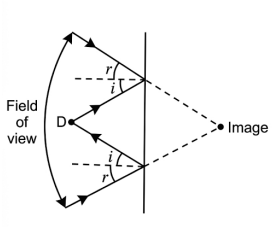
The uses of a concave mirror are as follows :

1. As a reflector: Concave polished metallic surfaces are commonly used in torches, search-lights and headlights of vehicles to get powerful parallel beams of light.
2. As a shaving mirror: When a concave mirror is held near the face such that the face is between the pole and the focus of the mirror, it gives an upright and magnified image of the face.
3. As a doctor's head mirror: The doctor's head mirror is used to concentrate a light beam on a small area of the ear, nose, throat, teeth etc. to be examined.
4. Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

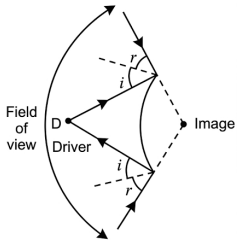
9. USES OF CONVEX MIRROR

The uses of a convex mirror are as follows :

1. As a reflector in street lamps: A convex metallic polished surface is used in street lamps so as to diverge the light over a larger area.
2. As rear-view mirrors in vehicles: Convex mirrors are preferred as rear-view mirrors because they always give an erect image, although diminished. Also, they have a wider field of view as they are curved outwards.



(a) Plane Mirror



(b) Convex Mirror

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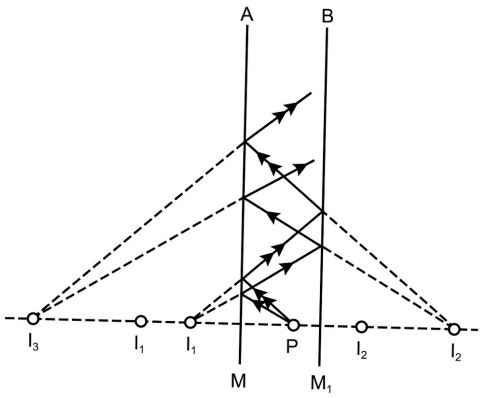
2.5 Images Formed in Two Inclined Mirrors

1. Light rays reflect from one mirror and are incident on another which reflects it again. Thus, we can say that the image formed by one mirror acts as the object for the other.
2. Let us say that θ is the angle between the two mirrors
3. If n= $\frac{360}{\theta}$ is odd, then the number of images formed
4. is n when the object is placed asymmetrically between the two mirrors.
5. If n= $\frac{360}{\theta}$ 0 is odd, then the number of images formed is $n-1$ when the object is placed symmetrically between the two mirrors.
6. If n= $\frac{360}{\theta}$ is even, then the number of images formed is always $n-1$ no matter how the object is placed between the two mirrors.

Images Formed by Two Mirrors Placed Parallel to Each Other

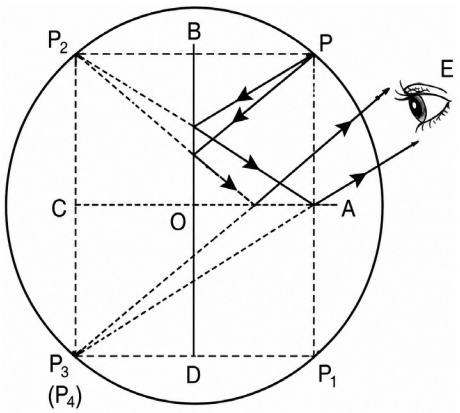
7. The number of images formed in this case will be infinite as $n = \frac{360}{\theta} = \infty$.



8. In this case, $n = \frac{360}{\theta} = 4$.

   Thus, the number of images will be $n - 1 = 3$.

Uses of Plane Mirror



9. An optician has a plane mirror mounted on the front wall where a patient sits and a sign board on the back wall.
10. In a kaleidoscope, three plane mirrors are inclined at an angle of 60° to each other. This forms some very beautiful patterns with the help of a few glass pieces.
11. In a barber's shop, two mirrors face each other so that a person can see the hair at the back of the head.
12. In a periscope, two mirrors are inclined at 45° with the vertical walls kept facing each other.

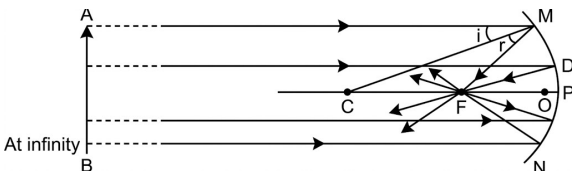
3. SPHERICAL MIRRORS

A reflecting surface which is a part of a sphere is called a spherical mirror. A spherical mirror whose reflecting surface is curved outwards and polished on the inner spherical surface is a convex mirror.

1. A spherical mirror whose reflecting surface is curved inwards and polished on the outer spherical surface is a concave mirror.
2. The geometric centre of the reflecting surface of a spherical mirror is a point called the pole.
3. The reflecting surface of a spherical mirror forms a part of a sphere. The centre of this sphere is called the centre of curvature of a spherical mirror. It is represented by C.
4. The horizontal line passing through the centre of curvature and the pole of the spherical mirror is known as the principal axis.
5. The radius of curvature of a spherical mirror is the radius of the sphere of which the reflecting surface of the spherical mirror is a part and is represented by R.
6. The part of the mirror which is exposed to incident light is called the aperture of the mirror. Thus, it is the surface from which reflection occurs.

4. FOCUS AND FOCAL LENGTH

1. The point at which a number of parallel rays intersect on the principal axis after reflecting from the mirror is called the principal focus of a concave mirror. It is represented by F.



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A plane mirror is manufactured by applying a highly reflective metallic coating on one side of a glass sheet. To strictly protect this delicate reflective layer from scratches and chemical damage, a thin protective layer of red lead oxide applies.

6. **Assertion (A) :** We can see objects like tables and chairs from almost any direction in a completely illuminated room.
Reason (R) : Rough surfaces produce diffused reflection, scattering the incident light uniformly in all alternative directions.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Light falling on naturally rough surfaces undergoes irregular or diffused reflection, meaning it scatters in numerous random directions rather than a single path. This diffused reflection allows non-metallic and unpolished everyday objects to be visibly observed from almost anywhere.

7. Which of the following accurately defines the plane of reflection according to optical laws?
(A) The plane containing the incident ray and the normal
(B) The plane containing the reflected ray and the normal
(C) The plane containing the incident ray and the reflected ray only
(D) The flat plane representing the physical mirror surface

Ans : (B)

The plane of reflection is strictly defined as the geometrical plane that contains both the reflected ray and the normal directly drawn at the precise point of incidence. According to the laws of reflection, it also holds the incident ray.

8. A light ray strikes a plane mirror such that the angle between the incident ray and the mirror surface is exactly forty degrees. What is the corresponding angle of reflection?
(A) 40 degrees
(B) 50 degrees
(C) 90 degrees
(D) 100 degrees

Ans : (B)

The angle of incidence is the geometric angle between the incident ray and the normal. Since the normal is strictly perpendicular to the flat mirror, this angle is ninety minus forty, equalling fifty degrees. The reflection angle perfectly matches this.

9. The table below lists the properties of two types of images, P and Q, formed by reflection.

Property	Image P	Image Q
Formation	Formed when light rays actually meet after reflection.	Formed when light rays appear to meet after reflection.
Projection	Can be obtained on a screen.	Cannot be obtained on a screen.
Orientation	Is always inverted with respect to the object.	Is always erect with respect to the object.

A plane mirror always forms which type of image?
(A) Image P, because it can be captured on a screen.
(B) Image Q, because it is erect and cannot be formed on a screen.
(C) Image P, because the rays of light intersect.
(D) Both Image P and Image Q, depending on object distance.

Ans : (B)

An image formed by a plane mirror is always virtual, erect, and cannot be projected onto a screen. These characteristics perfectly match the description of Image Q in the table. Image P describes a real image, which is inverted and formed by the actual intersection of light rays, a type not produced by a single plane mirror.

10. If a particular ray of light is incident normally on a flat plane mirror, what will be the resulting angle of reflection?
(A) 90 degrees
(B) 180 degrees
(C) 0 degrees
(D) 45 degrees

Ans : (C)

When a light ray strikes a plane mirror normally, it completely travels along the perpendicular normal line. This means the angle between the incident ray and the normal is exactly zero degrees. Consequently, the angle of reflection becomes exactly zero.

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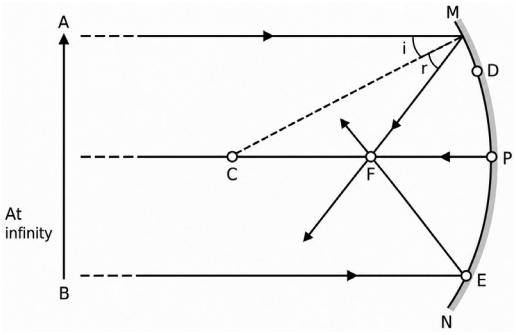
6. RAY DIAGRAMS FOR FORMATION OF IMAGES: CONCAVE MIRROR

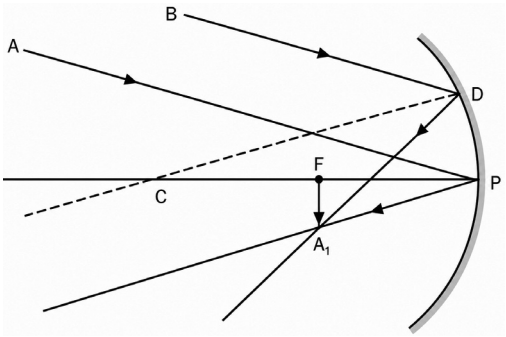
CASE (i):

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F	Diminished to point-sized	Real



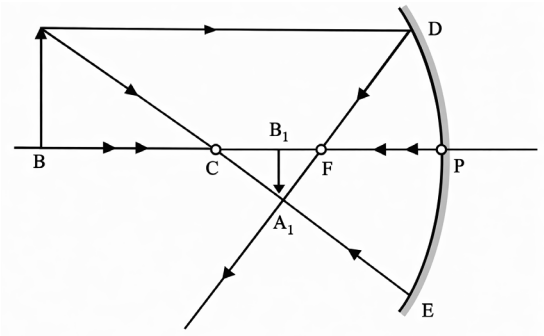
Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F	Highly Diminished	Real and inverted

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F	Diminished to point-sized	Real



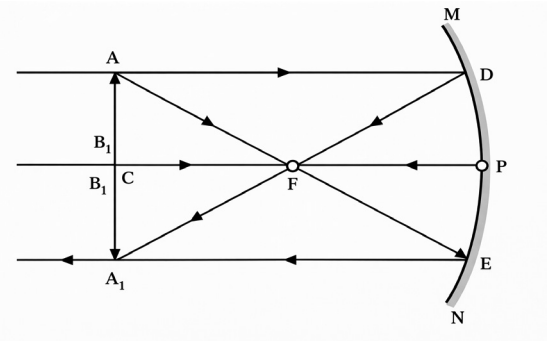
CASE (ii):

Position of object	Position of image	Size of image	Nature of image
Beyond C	Between F and C	Diminished	Real and inverted



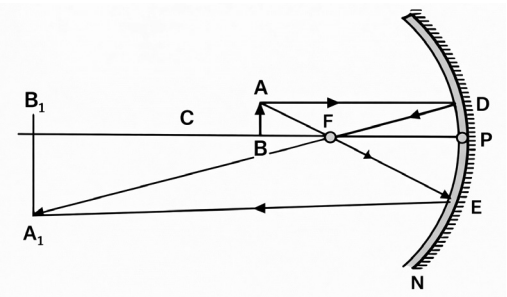
CASE (iii):

Position of object	Position of image	Size of image	Nature of image
At C	At C	Same size	Real and inverted



CASE (iv):

Position of object	Position of image	Size of image	Nature of image
Between C and F	Beyond C	Magnified	Real and inverted



CASE (v):

Position of object	Position of image	Size of image	Nature of image
At F	At infinity	Highly magnified	Real and inverted

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artificially extended backward behind the mirror. Therefore, the resulting image is purely virtual and proportionally equidistant.

16. **Assertion (A) :** For a standard plane mirror, the normal distance of the object from the mirror is absolutely equal to the normal distance of the image from the mirror.
Reason (R) : The geometric triangles formed by the incident and reflected rays with the central normal are mathematically congruent.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

A direct geometric proof undeniably shows that the right-angled triangle formed by the real object and the normal is exactly congruent to the right-angled triangle formed by the virtual image and the normal. This strictly confirms identical perpendicular distances.

17. Which of the following is NOT a true physical characteristic of an optical image formed directly by a standard plane mirror?
(A) The image formed is strictly virtual.
(B) The image formed is laterally inverted.
(C) The image formed is visibly magnified.
(D) The image formed is completely erect.

Ans : (C)

A standard plane mirror consistently produces an image that is always virtual, strictly erect, and completely laterally inverted. However, it absolutely never produces a magnified or diminished image. The final image size permanently remains strictly identical to the object size.

18. A young girl is standing exactly 4 meters away from a vertical plane mirror. If she suddenly moves 2 meters further away from the mirror, what will be the exact new distance between her and her virtual image?
(A) 6 meters
(B) 8 meters
(C) 12 meters
(D) 16 meters

Ans : (C)

Initially, she is exactly four meters away. Moving two meters further makes her new object distance exactly six meters. Because the virtual image symmetrically forms at an equal distance behind the mirror, the total separating distance becomes exactly twelve meters.

19. An object is placed at various distances in front of a plane mirror, and the corresponding distance of the image from the mirror is recorded.

Trial	Object Distance (u) from mirror	Image Distance (v) from mirror
1	10 cm	10 cm
2	25 cm	25 cm
3	40 cm	Z

Based on the characteristics of image formation by a plane mirror, what is the value of Z?
(A) 20 cm
(B) 40 cm
(C) 60 cm
(D) 80 cm

Ans : (B) 40 cm

A key characteristic of a plane mirror is that the image is formed as far behind the mirror as the object is in front of it. This means the object distance (u) is always equal to the image distance (v). Since the object distance in Trial 3 is 40 cm, the image distance (Z) must also be 40 cm.

20. If a small object moves with a constant speed v directly towards a fixed plane mirror, how does the resulting image visibly appear to move relative to the moving object?
(A) It appears to move with a speed v strictly towards the mirror.
(B) It appears to move with a speed 2v directly towards the object.
(C) It visibly appears to remain completely stationary in space.
(D) It appears to move with a slow speed v/2 towards the object.

Ans : (B)

When any object aggressively approaches a plane mirror at speed v, the virtual image equally approaches the mirror at speed v from the exact opposite direction. Therefore, the combined relative speed at which the image approaches the object equals 2v.

21. If a bright object is strategically placed between two strictly parallel plane mirrors, why do we not clearly see an infinite number of images, even though mathematically infinite images should be formed?

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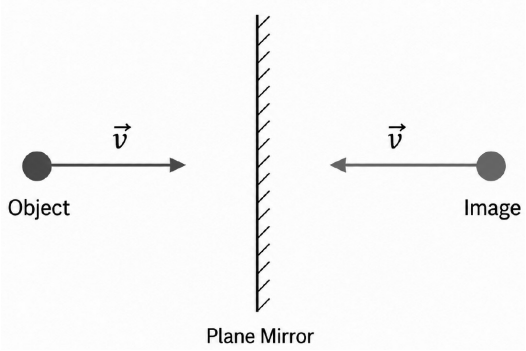
(A) The mirrors eventually stop reflecting light completely after exactly ten reflections.
(B) The optical distance simply becomes much too large for the human eye to focus.
(C) The visual brightness sharply decreases because some light gets absorbed at each reflection.
(D) The continuous images laterally invert each time, visually cancelling each other out completely.

Ans : (C)

Two parallel plane mirrors theoretically generate a completely infinite number of images. However, with every single successive reflection, a significant portion of light energy is strictly absorbed by the mirror surfaces. This progressive absorption rapidly diminishes remote image brightness entirely.

22. The diagram shows an object moving with a speed 'v' towards a stationary plane mirror.



(A) v, towards the object
(B) v, away from the object
(C) 2v, towards the object
(D) 0, as the mirror is stationary

Ans : (C)

Explanation: The image in a plane mirror moves at the same speed as the object, but in the opposite direction relative to the mirror. If the object approaches the mirror at speed v, the image also approaches the mirror at speed v. The relative speed of approach between the object and image is the sum of their individual speeds: v + v = 2v.

23. If the exact angle measured between two large plane mirrors is 60 degrees, what is the exact number of virtual images formed for any given object placed symmetrically between them?
(A) 5
(B) 6
(C) 7
(D) 4

Ans : (A)

Dividing three hundred sixty strictly by sixty clearly gives six, which is a perfect even number. For any given even ratio, whether the object is placed symmetrically or asymmetrically, the final number of total images strictly requires subtracting one, yielding five.

24. **Assertion (A) :** Two vertical plane mirrors kept exactly perpendicular to each other strictly form exactly three individual images of an object placed between them.
Reason (R) : When the geometric ratio of 360 degrees to the inclination angle is perfectly even, the number of images formed is always exactly one less than this ratio.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

For explicitly perpendicular mirrors, the precise angle is ninety degrees. Dividing three hundred sixty by ninety strictly gives four, a completely even number. Following the established mathematical rule for even ratios, the final number of images is fundamentally four minus one.

25. Match the image types with their corresponding physical characteristics.
List-I
P. Real image
Q. Virtual image
R. Image by a convex mirror
S. Image of distant object by a concave mirror
List-II
I. Always inverted and obtained on a screen
II. Cannot be obtained on a screen and is erect
III. Perfectly valid example of a virtual image
IV. Perfectly valid example of a real image
(A) P-I, Q-II, R-III, S-IV
(B) P-II, Q-I, R-IV, S-III
(C) P-I, Q-II, R-IV, S-III
(D) P-II, Q-I, R-III, S-IV

Ans : (A)

A real image strictly occurs when light rays actually intersect and is consistently inverted, visible on a screen. A virtual image predictably forms when rays mathematically appear to

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diverge, remaining upright. Concave mirrors form real images, unlike convex mirror variants.

26. A student tabulates the primary characteristics of an image formed by a plane mirror. One of the entries is missing.

Characteristic	Description
Nature	Virtual
Orientation	Erect (Upright)
Size	Y
Lateral Inversion	Left and right sides are interchanged

Based on the properties of images formed by a plane mirror, what is the correct description for 'Y'?
(A) Diminished in size compared to the object.
(B) Enlarged in size compared to the object.
(C) Same size as the object.
(D) Varies with the distance from the mirror

Ans : (C)

One of the fundamental characteristics of an image formed by a plane mirror is that its size is exactly equal to the size of the object. Therefore, the magnification is always 1. The image is neither diminished nor enlarged, regardless of the object's distance from the mirror, making option (C) the only correct choice.

27. How many long plane mirrors are practically used in a standard kaleidoscope, and at what specific angle are they generally inclined to function properly?
(A) Exactly two rectangular mirrors rigidly inclined at 90 degrees.
(B) Exactly three rectangular mirrors rigidly inclined at 60 degrees.
(C) Exactly four rectangular mirrors rigidly inclined at 45 degrees.
(D) Exactly three rectangular mirrors rigidly inclined at 90 degrees.

Ans : (B)

A highly typical kaleidoscope relies exactly on three long rectangular plane mirrors completely arranged together to physically form a triangular prism structure. These rigid mirrors are completely inclined at exactly sixty degrees to one another, which systematically generates continuous multiple reflections.

28. If an athletic young girl continuously runs directly towards a perfectly stationary plane mirror strictly at a constant speed of 3 m/s, at what exact speed does her virtual image strictly move directly towards the fixed mirror?
(A) 1.5 m/s
(B) 3 m/s
(C) 6 m/s
(D) 9 m/s

Ans : (B)

The pure virtual image cleanly formed by a fixed plane mirror strictly remains constantly at the exact same proportional perpendicular distance behind it as the physical object is in front. Therefore, the image strictly approaches the mirror directly at exactly 3 m/s.

29. If a given incident light ray is strictly kept fixed and the supporting plane mirror is carefully turned through an angle of exactly 10 degrees, by what specific angle will the final reflected ray turn?
(A) 5 degrees
(B) 10 degrees
(C) 15 degrees
(D) 20 degrees

Ans : (D)

There is a completely fundamental optical rule regarding dynamically rotating plane mirrors. If an incident light ray remains absolutely constant and the mirror structurally rotates by a specific given angle, the corresponding reflected ray always rigidly turns by exactly twice that.

30. Why do professional opticians frequently place a flat plane mirror directly in front of a medical patient to carefully read a standard chart kept physically behind the patient?
(A) To laterally invert the printed letters so they are completely readable.
(B) To strictly increase the total effective optical length of the small testing room.
(C) To magically magnify the physical size of the small letters on the testing chart.
(D) To explicitly create a much sharper real image that is functionally easier to read.

Ans : (B)

Clinical opticians intelligently use a plane mirror to practically double the testing distance within a restricted room. Light carefully travels to the mirror and strictly reflects back to the patient, thereby artificially increasing the total effective viewing distance visually required.

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40. In a standard optical kaleidoscope, what precisely causes the beautiful hexagonal visual patterns to drastically change exactly when the tube is dynamically rotated?
(A) The exact geometric angle strictly between the mirrors changes directly from 60 to 90 degrees.
(B) The small loose coloured beads dynamically shift internal positions continuously between the mirrors.
(C) The actual optical focal length strictly of the rigid mirrors changes completely dynamically.
(D) The complete lateral visual inversion strictly of the rigid mirrors is instantly completely reversed.

Ans : (B)

A classic optical kaleidoscope relies strictly on three internal mirrors rigidly angled precisely at sixty degrees, safely containing completely loose bright coloured beads. Dynamically rotating the tube physically shifts these loose beads strictly into entirely new random positions, continuously generating fresh optical patterns.

41. What is the fundamental definition of a spherical mirror according to the laws of reflection?
(A) A mirror whose reflecting surface is completely flat and smooth on one side
(B) A mirror whose reflecting surface is a part of a hollow sphere of glass silvered on one side
(C) A mirror composed exclusively of solid glass with no silvered coating
(D) A mirror that always converges light rays to a single real point

Ans : (B)

A spherical mirror is accurately defined as a mirror whose reflecting surface is a part of a hollow sphere of glass silvered on one side. The laws of reflection for plane surfaces completely hold true and good for spherical mirrors.

42. **Assertion (A) :** A purely real image absolutely cannot be properly formed strictly by a single standard plane mirror under absolutely normal isolated circumstances.
Reason (R) : Light rays purely coming from a strictly real physical point object completely diverge heavily after pure reflection from a flat plane mirror and completely never actually intersect.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

A completely real optical image strictly requires the completely actual physical intersection explicitly of the actively reflected traveling light rays. Because a perfectly flat plane mirror completely causes incident light rays purely from a strictly point source to completely permanently diverge.

43. A student investigates the relationship between the angle of inclination of two plane mirrors and the number of images formed of an object placed between them.

Trial	Angle between Mirrors (q)	Number of Images Formed
1	90°	3
2	60°	5
3	45°	7
4	30°	?

Based on the trend observed in the table, what can be concluded about the relationship?
(A) As the angle decreases, the number of images decreases.
(B) As the angle decreases, the number of images increases.
(C) As the angle decreases, the number of images remains the same.
(D) There is no relationship between the angle and the number of images.

Ans : (B)

The number of images is calculated by $(360°/\theta) - 1$. As the angle θ in the denominator decreases, the value of the fraction $360°/\theta$ increases. Consequently, the total number of images formed increases. The table clearly demonstrates this inverse relationship: as θ drops from 90° to 45°, the number of images rises from 3 to 7.

44. When a small distinct object is properly placed perfectly strictly between two completely perpendicular flat plane mirrors, exactly three virtual images are clearly formed. Why exactly is the very third completely distinct overlapping image strictly formed?
(A) It is explicitly formed strictly by completely direct reflection exactly from the central bisector line.
(B) The precise first image strictly in one specific mirror acts completely as a pure virtual object securely for the second exact mirror.

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Ans : (A)

A decidedly thick glass plane mirror causes complicated multiple internal light reflections bouncing between its front and back surfaces. The first faint image comes from the unsilvered front surface, while the undeniably brightest second image strictly results from the strongly silvered back.

36. In a typical optical periscope actively used by military submarines, how exactly are the two required plane mirrors physically arranged inside the long tube?
(A) Completely parallel to each other and rigidly inclined at exactly 45 degrees to the vertical walls.
(B) Strictly perpendicular to each other and safely inclined at 60 degrees.
(C) Completely parallel to each other and strictly inclined at 90 degrees to the vertical walls.
(D) Rigidly inclined at strictly 30 degrees to each other while facing opposite geometric directions.

Ans : (A)

A standard military periscope explicitly utilizes two flat plane mirrors directly facing each other. These two mirrors are positioned completely parallel to one another while being rigidly fixed at exactly a forty-five degree physical angle strictly relative to the internal walls.

37. Match the precise angle of inclination strictly between two plane mirrors directly with the correct number of distinct images formed for an object carefully placed exactly asymmetrically.
List-I
P. 90 degrees strictly
Q. 60 degrees strictly
R. 72 degrees strictly
S. 0 degrees completely (strictly parallel mirrors)
List-II
I. Exactly 5 images
II. Exactly 4 images
III. Completely infinite images
IV. Exactly 3 images
(A) P-IV, Q-I, R-I, S-III
(B) P-I, Q-IV, R-II, S-III
(C) P-IV, Q-II, R-I, S-III
(D) P-II, Q-I, R-IV, S-III

Ans : (A)

At ninety degrees, the mathematical ratio strictly equals four, rendering exactly three clear images. At sixty degrees, the ratio perfectly equals six, rendering exactly five images. At strictly seventy-two degrees asymmetric, it strictly yields five. Parallel mirrors predictably generate fully infinite images.

38. What specific physical phenomenon occurs exactly when a parallel beam of light directly strikes the surface of a highly rough non-metallic material?
(A) It strictly gets absorbed completely without any active reflection.
(B) It completely reflects perfectly as a single distinct parallel beam.
(C) It rapidly bounces off scattered in many numerous alternative directions irregularly.
(D) It explicitly creates a perfectly clear and highly distinct virtual image.

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Ans : (C)

Natural, entirely non-metallic surfaces typically possess significant microscopic roughness. When parallel incident light rays directly strike these completely unpolished surfaces, they aggressively bounce off scattering in numerous extremely random directions. This fundamental phenomenon is completely termed irregular or widely diffused reflection.

39. Consider the following specific statements regarding the fundamental laws of reflection:
I. The angle of incidence is strictly the angle precisely between the incident ray and the flat mirror surface.
II. The optical angle of reflection completely always exactly equals the exact angle of incidence.
III. The incident ray, strictly the reflected ray, and the actual mirror surface lie completely in the exact same plane.
IV. The defined normal is strictly a perpendicular precisely drawn to the surface perfectly at the exact point of incidence.
Which of the given statements are correct?
(A) I and III
(B) II and IV
(C) I, II, and IV
(D) II, III, and IV

Ans : (B)

Statement one is completely incorrect because the optical angle of incidence is strictly and only measured directly from the geometric normal. Statement three is thoroughly incorrect because it is the perpendicular normal, absolutely not the entire mirror surface itself, that perfectly shares the plane.

mirror.

49. In spherical mirrors, the normal drawn at any point on the reflecting surface always passes strictly through which specific geometrical location?
(A) The pole of the mirror
(B) The principal focus of the mirror
(C) The centre of curvature
(D) Infinity

Ans : (C)

In spherical mirrors, the line joining any arbitrary point on the reflecting surface directly to the centre of curvature always acts as the geometric normal. This fundamental property continuously ensures that incident rays passing through the centre reflect identically backward.

50. A vertical plane passing precisely through the principal focus and remaining normal to the principal axis is fundamentally known as:
(A) The reflecting plane
(B) The linear aperture
(C) The focal plane
(D) The angular aperture

Ans : (C)

The focal plane is fundamentally defined as a vertical plane passing exactly through the principal focus and remaining completely perpendicular to the principal axis. Parallel beams inclined to the axis will converge at a specific point on this exact plane.

51. Evaluate the following statements regarding the Cartesian sign convention for measuring distances in spherical mirrors:
I. The object is always placed to the left side of the mirror.
II. Distances measured in the direction of incident light are securely positive.
III. Distances measured upward and strictly above the principal axis are strictly negative.
IV. The pole of the reflecting mirror is uniformly taken as the origin.
Which of the above statements are correct?
(A) I, II, and III only
(B) II, III, and IV only
(C) I, II, and IV only
(D) I and IV only

Ans : (C)

According to standard sign conventions, the object remains on the left, and the mirror's pole acts as the origin. Distances matching the incident light direction remain positive, while heights measured straight upward above the principal axis are distinctly measured positive.

52. **Assertion (A) :** An incident ray passing through the centre of curvature of a concave mirror completely retraces its path after reflection.
Reason (R) : The incident ray falls on the mirror along the normal to the reflecting surface, making the angle of incidence zero.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Any line drawn directly from the centre of curvature to the spherical mirror acts as a normal to the surface. Since the incident ray strikes exactly at an angle of zero degrees, it reflects backward along its exact original path.

53. The table below describes the mirror arrangement in various optical instruments.

Device	**Number of Plane Mirrors**	**Typical Inclination Angle of Mirrors**
Simple Periscope	2	X
Kaleidoscope	3	60° to each other
Barber's Shop	2	0° to each other (parallel)

What is the correct value of X required for a simple periscope to allow a user to see over an obstacle?
(A) 0° to the vertical
(B) 30° to the vertical
(C) 45° to the vertical
(D) 90° to the vertical

Ans : (C)

A simple periscope uses two parallel plane mirrors to displace the line of sight. Each mirror is inclined at an angle of 45° to the vertical walls of the tube. This arrangement causes the light to turn 90° at the first mirror and another 90° at the second, effectively directing the image to the observer's eye.

54. Consider the following rules used as convenient rays for the construction of spherical mirror images:
I. A ray parallel to the principal axis reflects precisely through the focus.

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(C) The traveling light rays strictly undergo significant optical refraction directly between the two distinct mirrors.
(D) The two rigid mirrors are both physically completely laterally inherently inverted.

Ans : (B)

In precisely two exactly perpendicular rigid mirrors, the explicit first mirror perfectly creates an initial purely virtual image. This initial image directly then uniquely acts strictly as a secondary completely virtual object specifically for the other perpendicular mirror, ultimately generating a third distinct overlapping reflection.

45. Why exactly is a strictly flat plane mirror carefully placed directly under the standard scale and reading pointer perfectly in some highly precise measuring instruments?
(A) To optically strongly magnify the entire detailed reading directly for much easier simple viewing.
(B) To thoroughly uniquely ensure the distinct thin pointer gets completely safely laterally cleanly inverted.
(C) To strictly actively perfectly avoid dangerous parallax reading errors and securely clearly get the completely purely correct precise reading.
(D) To virtually successfully directly completely increase the total exact visible length strictly of the pointer entirely purely virtually.

Ans : (C)

High precision modern measuring instruments cleverly tightly incorporate a purely flat perfectly straight strip of shiny plane mirror perfectly directly beneath the moving pointer. The human observer must strictly physically align the actual distinct pointer completely perfectly exactly with its very own distinct reflection purely.

46. Match the spherical mirror terms in List-I with their correct definitions in List-II.
List-I
P. Pole
Q. Centre of curvature
R. Linear aperture
S. Principal axis
List-II
I. Midpoint of the reflecting curved surface
II. Centre of the imaginary sphere of glass
III. Length of the straight line joining endpoints
IV. Imaginary line passing through pole and centre
(A) P-I, Q-II, R-III, S-IV
(B) P-II, Q-I, R-IV, S-III
(C) P-III, Q-IV, R-I, S-II
(D) P-IV, Q-III, R-II, S-I

Ans : (A)

The pole is the midpoint of the mirror. The centre of curvature represents the imaginary sphere's centre. Linear aperture measures the straight line distance between mirror endpoints. The principal axis is the line connecting the pole and centre of curvature.

47. Consider the following statements regarding light rays incident on a spherical mirror:
I. Paraxial rays are parallel and close to the principal axis.
II. Marginal rays strike the reflecting surface near its outer boundary.
III. Marginal rays make very small angles of incidence.
IV. Paraxial rays make very large angles of incidence.
Which of the above statements are correct?
(A) I and III only
(B) II and IV only
(C) I and II only
(D) III and IV only

Ans : (C)

Paraxial rays remain parallel and close to the principal axis, making extremely small angles of incidence. Marginal rays strike the reflecting surface near the outer boundary, making larger angles. Thus, only the first two statements describe these specific rays perfectly.

48. **Assertion (A) :** The principal focus of a concave mirror is real, whereas the principal focus of a convex mirror is virtual.
Reason (R) : Rays parallel to the principal axis actually meet at the focus in a concave mirror but only appear to meet in a convex mirror.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

A concave mirror converges parallel light rays so they actually intersect at the focus, making it a real point. A convex mirror diverges parallel rays, making them appear to originate from a virtual focus situated completely behind the reflecting

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fifteen centimetres exactly.

60. The linear magnification produced by a spherical mirror for a completely real and inverted image logically carries which mathematical sign?
(A) Strictly positive
(B) Strictly negative
(C) Zero
(D) Both positive and negative equally

Ans : (B)

Linear magnification expresses the precise ratio of image height to object height. For any real image, it appears completely inverted, producing a negative measurement below the axis. Consequently, real images consistently feature a definitively negative calculated linear magnification numerical value.

61. Which specific type of mirror is most commonly preferred and utilized effectively as a shaving mirror?
(A) A plane mirror only
(B) A convex mirror with a small focal length
(C) A concave mirror with a large focal length
(D) A convex mirror with a large focal length

Ans : (C)

A concave mirror featuring a large focal length efficiently functions as a shaving mirror. When a face rests intimately between the pole and focus, the mirror reliably generates a highly magnified, virtual, and erect image, clearly revealing tiny facial hairs.

62. For a concave mirror, the distinct geometric point strictly located on the principal axis where all initially parallel incident rays actually converge after reflection is defined as the:
(A) Centre of curvature
(B) Pole
(C) Linear aperture
(D) Principal focus

Ans : (D)

The principal focus of a concave mirror indicates the precise spot on the principal axis where all incident light rays travelling parallel to this axis actually intersect together immediately after reflecting accurately from the mirror's inner curved glass reflecting surface.

63. **Assertion (A) :** Drivers prominently utilize convex mirrors as standard rear-view mirrors in their various automobiles.
Reason (R) : Convex mirrors deliberately diverge incident light, thereby providing a significantly wider field of view compared to plane mirrors of similar size.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Drivers heavily rely on convex mirrors to monitor rear traffic because these specific mirrors deliberately diverge incident light. This characteristic fundamentally ensures a noticeably broader field of view while continually presenting small, erect, and virtual images of approaching heavy vehicles.

64. Why is a convex polished metallic surface prominently chosen as a reflector in modern street lamps?
(A) It strictly converges light rays into a highly intense parallel beam
(B) It forcibly diverges light rays effectively over a significantly larger surrounding area
(C) It forms real and magnified images of the internal light bulb
(D) It completely prevents light rays from scattering upward into the sky

Ans : (B)

Convex mirrors are prominently installed in standard street lamps specifically as reflectors. Their distinctly bulging outer surfaces forcibly diverge incident light rays over a significantly larger surrounding area, actively ensuring widespread illumination across dark streets and busy public walking pathways.

65. Identify the fundamentally correct statements differentiating a concave mirror from a standard convex mirror:
I. A concave mirror reflects light strictly from its inner curved surface.
II. A convex mirror reflects light effectively from its outer bulging surface.
III. A concave mirror is broadly categorized strictly as a diverging mirror.
IV. A convex mirror is technically referred to as a converging mirror.
(A) I and II only
(B) III and IV only
(C) I, II, and III only
(D) II, III, and IV only

Ans : (A)

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II. A ray passing through the focus reflects parallel to the principal axis.
III. A ray passing through the centre of curvature reflects parallel to the principal axis.
IV. A ray passing through the pole reflects back along the same path.
Which of the above rules are entirely correct?
(A) I and II only
(B) II and III only
(C) III and IV only
(D) I, II, and IV only

Ans : (A)

Light rays travelling parallel to the principal axis reflect precisely through the focus. Rays passing through the focus reflect parallel to the axis. Rays passing through the centre of curvature completely retrace their original paths, never reflecting parallel to it.

55. What are the specific characteristics of an image formed when an object is placed safely beyond the centre of curvature of a concave mirror?
(A) Real, erect, and magnified
(B) Virtual, inverted, and diminished
(C) Real, inverted, and diminished
(D) Virtual, erect, and magnified

Ans : (C)

When an object is securely placed beyond the centre of curvature of a concave mirror, the reflected rays intersect strictly between the focus and the centre of curvature. This intersection always produces a real, inverted, and noticeably diminished image geometrically.

56. **Assertion (A) :** A convex mirror consistently forms a virtual, erect, and magnified image irrespective of the actual object position.
Reason (R) : The light rays incident on a convex mirror always diverge after reflection, causing them to appear to intersect behind the mirror.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (D)

A convex mirror consistently creates virtual, erect, and diminished images for all real objects. However, the incident light rays always diverge after reflecting off the bulging outer surface, causing them to only appear intersecting at a hidden virtual focal point.

57. Match the object positions in List-I with their corresponding image positions for a concave mirror in List-II.
List-I
P. At infinity
Q. At centre of curvature
R. Between pole and focus
S. At principal focus
List-II
I. Behind the mirror
II. At infinity
III. At centre of curvature
IV. At principal focus
(A) P-IV, Q-III, R-I, S-II
(B) P-I, Q-II, R-III, S-IV
(C) P-IV, Q-I, R-III, S-II
(D) P-III, Q-IV, R-II, S-I

Ans : (A)

Placing an object at infinity produces an image exactly at the focus. An object at the centre of curvature forms an equally sized image there. An object between the pole and focus yields an enlarged image directly behind the mirror.

58. When a physical object is stationed at a finite distance in front of a convex mirror, the corresponding image formed is strictly:
(A) Real, inverted, and diminished
(B) Virtual, erect, and diminished
(C) Virtual, erect, and magnified
(D) Real, inverted, and magnified

Ans : (B)

For any object placed at a finite distance in front of a convex mirror, the diverging reflected rays must be produced backwards to intersect. This effectively forms a virtual, erect, and diminished image strictly between pole and principal focal point.

59. A concave mirror possesses a measured radius of curvature exactly equal to 30 cm. What is its numerical focal length according to proper sign conventions?
(A) + 15 cm
(B) - 15 cm
(C) + 30 cm
(D) - 60 cm

Ans : (B)

The focal length of any spherical mirror strictly equals half its precise radius of curvature. Because distances measured contrary to incident light are assigned negative values, the focal length of this concave mirror calculates accurately as negative

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31. When a solid object is strategically placed between two inclined plane mirrors, all the various images formed rigorously lie on a very specific geometric path. What is this exact path?
(A) A straight line strictly perpendicular to the bisector of the two mirrors.
(B) A mathematical parabola with its focus exactly at the point of intersection.
(C) A perfect circle whose central point is exactly at the intersection of the mirrors.
(D) An elongated ellipse physically touching both reflective mirror surfaces.

Ans : (C)

When multiple virtual images properly form between two inclined reflective mirrors, they consistently map directly onto a circle's exact circumference. The physical centre of this circular geometric path is precisely the specific point where the two rigid mirror planes strictly intersect.

32. What is the precise minimum vertical height of a flat plane mirror physically required for an observer to completely see their own full-size standing image?
(A) One-fourth the total standing height of the observing person
(B) Exactly half the total standing height of the observing person
(C) Exactly equal to the total standing height of the observing person
(D) Exactly double the total standing height of the observing person

Ans : (B)

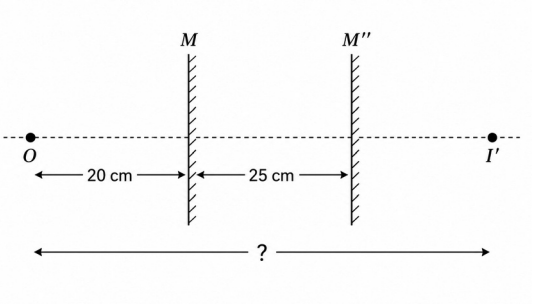
Through fundamental geometric optics and congruent triangles, it can be mathematically proven that fully viewing your completely upright body strictly requires a specifically precise dimension. The flat vertical length of the plane mirror must explicitly equal exactly half the observer's physical height.

33. Consider the following common applications and practical uses of flat plane mirrors:
I. Used in simple kaleidoscopes to dynamically produce beautiful hexagonal optical patterns.
II. Used in standard solar cookers to correctly reflect hot light rays.
III. Used as typical everyday household looking glasses.
IV. Used in commercial showcases to artificially provide false spatial dimensions.
Which of the given statements accurately represent their uses?
(A) I and II only
(B) I, III, and IV only
(C) II, III, and IV only
(D) I, II, III, and IV

Ans : (D)

Standard plane mirrors undoubtedly possess numerous highly practical applications. They consistently reflect intense sunlight into solar cookers, create perfectly symmetrical multiple reflections within kaleidoscopes, serve as standard everyday looking glasses, and artificially expand perceived space efficiently in luxury jewellery shop showcases.

34. An object O is initially placed 20 cm in front of a plane mirror M. The mirror is then moved 5 cm further away from the object to a new position M'.



(A) 40 cm
(B) 45 cm
(C) 50 cm
(D) 25 cm

Ans : (C)

Explanation: Initially, the object-mirror distance is 20 cm, so the object-image distance is 20 + 20 = 40 cm. When the mirror is moved 5 cm away, the new object-mirror distance becomes 20 + 5 = 25 cm. The new image will be 25 cm behind the new mirror position. The total distance between the object and the new image is 25 + 25 = 50 cm.

35. **Assertion (A) :** A distinctly thick glass plane mirror regularly produces multiple overlapping images of a single bright object, out of which the second visible image is always the brightest.
Reason (R) : The bright second image is strictly formed by the strong reflection exactly from the heavily silvered back surface of the glass block.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

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A concave mirror fundamentally reflects incoming light rays directly from its hollow inner curved surface, acting as a converging mirror. Conversely, a convex mirror reflects light strictly from its bulging exterior surface, successfully functioning as a dedicated diverging optical mirror.

66. When observing a reflection by bringing an unknown mirror intimately close to a face, the image appears noticeably erect and diminished in size. The given mirror is undoubtedly a:
(A) Plane mirror
(B) Concave mirror
(C) Convex mirror
(D) Parabolic mirror

Ans : (C)

When observing an image by bringing a mirror intimately close to a face, a magnified and erect reflection definitively identifies a concave mirror. If the resulting erect image appears noticeably diminished, the reflecting device is undoubtedly a standard convex mirror.

67. **Assertion (A) :** Concave mirrors can effectively generate both distinctly real and entirely virtual images depending directly upon the object's actual placement distance.
Reason (R) : Placing an object at infinity always results in a highly magnified, real, and inverted image at the pole.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

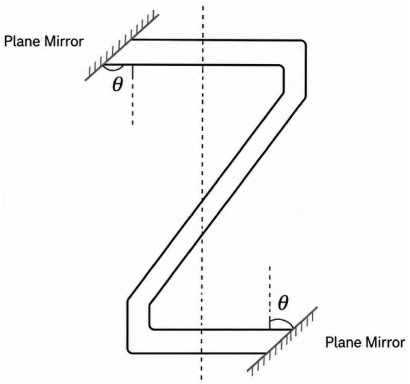
Concave mirrors dynamically create both real and virtual images based heavily on object distance. However, placing an object at infinity always results in converging rays forming a highly diminished, real, and inverted point image located strictly at the principal focus.

68. What specific optical device is frequently utilized to correct the failure of standard spherical mirrors to uniformly bring both paraxial and marginal rays exactly to a single focal point?
(A) Plane mirrors
(B) Parabolic mirrors
(C) Convex spherical mirrors
(D) Thick glass prisms

Ans : (B)

Standard spherical mirrors fail to bring marginal rays exactly to a single focus alongside paraxial rays. To actively correct this specific optical issue and successfully focus absolutely all parallel rays uniformly, specially designed parabolic mirrors are frequently utilized in practice.

69. The diagram shows the basic structure of a periscope, which uses two parallel plane mirrors.



(A) 30°
(B) 45°
(C) 60°
(D) 90°

Ans : (B)

In a simple periscope, light must be turned by 90° at each corner. For a ray of light to be deflected by 90° upon reflection, the incident ray must strike the mirror at an angle of incidence of 45°. This requires the mirror itself to be inclined at an angle of 45° to the path of the incoming light.

70. Evaluate the following analytical statements concerning the values of linear magnification (m) for spherical mirrors:
I. A positive magnification value confirms a virtual and distinctly erect image.
II. A negative magnification value guarantees a real and completely inverted image.
III. A unit magnitude strictly denotes identically matched physical object and image heights.
IV. A negative magnitude strictly indicates that the image is formed behind the mirror.
Which of the combinations correctly represents accurate facts?
(A) I, II, and III only
(B) II, III, and IV only
(C) I and IV only
(D) I, II, III, and IV

Ans : (A)

Linear magnification precisely indicates image

characteristics through its calculated sign and magnitude. A positive value confirms a virtual and erect image, whereas a negative value guarantees a real and inverted image. A unit magnitude denotes identically matched physical object heights.

71. An optical experiment dictates that an object be positioned securely at the centre of curvature of a concave mirror. What are the definitive characteristics of the resulting image?
(A) Virtual, erect, and identically sized
(B) Real, inverted, and magnified
(C) Real, inverted, and identically sized
(D) Virtual, inverted, and diminished

Ans : (C)

Whenever an object is securely stationed precisely at the centre of curvature of a concave mirror, the reflected rays accurately intersect at that exact same location. This interaction produces a real, inverted image possessing identically equivalent physical geometric dimensional measurements.

72. Which specific type of spherical mirror is actively utilized by medical professionals as a head mirror to expertly concentrate light beams onto a small diagnostic area?
(A) Convex mirror
(B) Plane mirror
(C) Concave mirror
(D) Parabolic convex mirror

Ans : (C)

Medical professionals actively utilize specially fitted concave head mirrors to expertly concentrate parallel beams of light directly onto small examination areas. The mirror successfully focuses incoming bright light onto targets like throats, greatly improving visual diagnostic clarity during medical procedures.

73. According to geometric optical laws, when an incident light ray squarely strikes the pole of a spherical mirror obliquely, which specific imaginary line successfully acts as the geometric normal?
(A) The chord representing linear aperture
(B) The focal plane
(C) The principal axis
(D) The marginal paraxial boundary

Ans : (C)

When an incident ray squarely strikes the pole of any spherical mirror obliquely, the principal axis successfully acts as the normal. The ray subsequently reflects obliquely, rigidly maintaining exactly equal angles of incidence and reflection relative to the principal axis.

74. The universally accepted spherical mirror formula accurately relates three distinct geometric distance values. Which essential practice strictly governs the proper substitution of these recognized numerical quantities into the equation?
(A) Using exclusively positive numbers
(B) Strictly applying established Cartesian sign conventions
(C) Ignoring the position of the mirror's pole
(D) Placing the object strictly on the right side

Ans : (B)

The universally accepted spherical mirror formula accurately relates the distinct values of object distance, image distance, and focal length. This fundamental mathematical equation strictly demands proper adherence to established sign conventions when substituting recognized numerical quantities during practical physics calculations.

75. A concave mirror consistently generates real and inverted images across various object locations. Which specific geometric placement effectively yields the sole exception, producing a virtual and erect image?
(A) Precisely at the centre of curvature
(B) Directly at the principal focus
(C) Securely positioned at infinity
(D) Precisely between the principal focus and pole

Ans : (D)

A concave mirror consistently generates real and inverted images across most standard object locations. The sole geometric exception effectively occurs when an object sits precisely between the principal focus and pole, yielding a magnified, virtual, and completely erect optical image.

76. For two flat plane mirrors kept precisely inclined to each other at a fixed angle of 72 degrees, if a point object is placed asymmetrically between them, how many exact images are formed?
(A) 4
(B) 5
(C) 6
(D) 7

Ans : (B)

The mathematical formula requires dividing three hundred sixty by seventy-two, which

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perfectly equals five. Since five is inherently an odd number and the object is deliberately placed asymmetrically, the final total number of formed images remains exactly five without subtraction.

77. During a laboratory demonstration, an object systematically travels from infinity toward a concave mirror. How does the position and size of the corresponding real image progressively change?
(A) It shifts closer to the pole and gradually diminishes in size.
(B) It strictly remains completely stationary precisely at the principal focus.
(C) It shifts farther away from the focal point and gradually expands in size.
(D) It shifts toward the focal point and immediately becomes a virtual image.

Ans : (C)

When an object systematically travels from infinity toward a concave mirror, the corresponding real image progressively shifts farther away from the focal point. Simultaneously, the initially diminished image size gradually expands until the object completely passes the principal focal point.

78. In an experiment to verify the laws of reflection, a student measures the angle of incidence (i) and the angle of reflection (r) for different trials.

S.N.	Angle X (in degree)	Angle Y (in degree)
1.	30	30
2.	40	40
3.	50	50
4.	60	P

Based on the second law of reflection, what do Angle X, Angle Y, and the value of P represent?
(A) X is angle of incidence, Y is glancing angle, P is 30°.
(B) X is angle of incidence, Y is angle of reflection, P is 60°.
(C) X is angle of reflection, Y is angle of incidence, P is 30°.
(D) X is glancing angle, Y is angle of incidence, P is 60°.

Ans : (B)

The second law of reflection states that the angle of incidence is equal to the angle of reflection (i = r). The consistent equality between the values in the columns for trials 1, 2, and 3 indicates that X represents the angle of incidence and Y represents the angle of reflection. Therefore, for trial 4, P must be 60°.

79. An engineer measures the precise radius of curvature of a polished convex mirror as exactly 36 cm. Applying standard Cartesian sign conventions, what is the mathematically exact focal length?
(A) - 18 cm
(B) + 18 cm
(C) - 72 cm
(D) + 72 cm

Ans : (B)

The focal length firmly remains exactly half of the designated radius of curvature. According to standardized Cartesian sign conventions, distances measured precisely in the exact direction of incident light denote positive values, making this convex mirror's focus strictly measure positive.

80. If a small physical object is placed securely and precisely at the principal focus of a standard concave mirror, where will the resulting final image effectively manifest?
(A) Precisely at the centre of curvature
(B) Directly at the mirror's pole
(C) Exactly at a distance equal to the focal length behind the mirror
(D) Effectively at vast infinity

Ans : (D)

Placing a physical object precisely at the principal focus of a concave mirror perfectly renders the reflected light rays completely parallel. Consequently, these non-intersecting parallel rays invariably form a highly magnified, real, and inverted image positioned effectively at vast infinity.

81. Identify the fundamentally INCORRECT statement regarding the rigid implementation of the Cartesian sign convention used in spherical mirror geometry calculations.
(A) The mirror's pole uniformly serves as the definitive origin point.
(B) Physical objects invariably reside strictly on the right side of the mirror.
(C) Distances measured straight upward above the principal axis are strictly positive.
(D) Horizontal distances matching the incident light direction remain exclusively positive.

Ans : (B)

Standard sign conventions strictly require measuring all horizontal distances directly from

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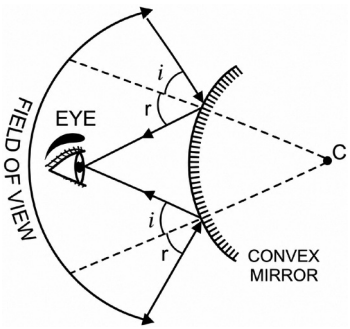
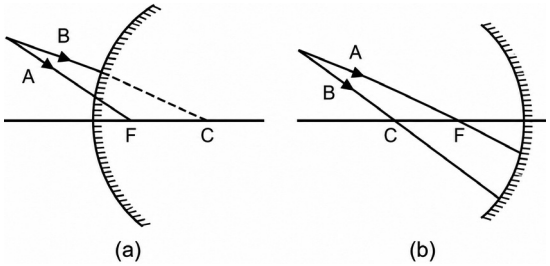
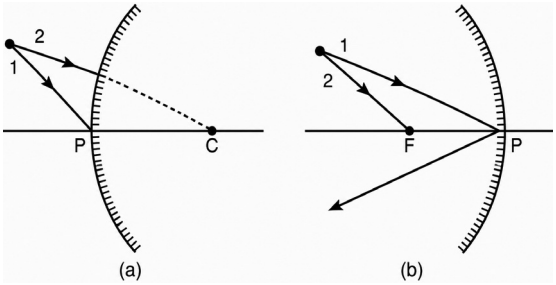


135. Complete the following diagrams shown in figure by drawing the reflected ray for each of the incident ray A and B.



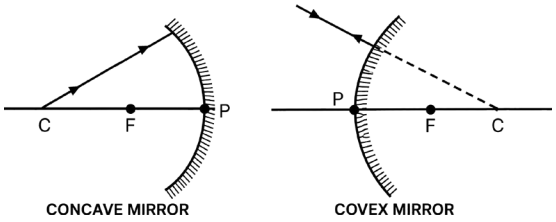
Ans :



136. State the direction of incident ray which after reflection from a spherical mirror retraces its path. Give a reason to your answer.

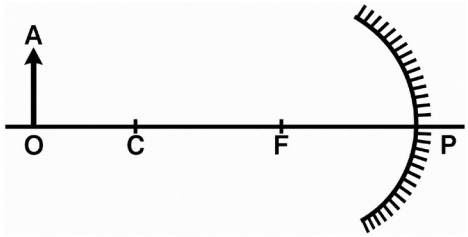
Ans :

Direction of incident ray is normal to the mirror. Reason. A line joining the centre of curvature to any point on the surface of mirror is always normal to it.

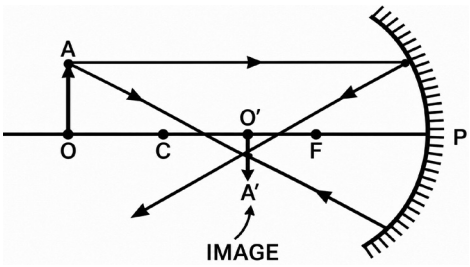


Therefore, a ray passing through the centre of curvature or appearing to pass through the centre of curvature is incident normally on the spherical mirror. Its angle of incidence is zero. Therefore, angle of reflection is zero and ray gets reflected back along its own path.

137. Fig. Shows a concave mirror with its pole at P, focus F and centre of curvature C. Draw ray diagram to show the formation of image of an object OA.



Ans :



138. Light from a torch is reflected by a white sheet of paper and a black polished mica sheet. Which of the two will produce a stronger reflected beam ?

Ans :

A white sheet of paper will produce a stronger reflected beam than a black polished mica sheet. This is because a white surface reflects all the colours in the visible spectrum, while a black surface absorbs all the colours in the visible spectrum. When light from a torch falls on a white sheet of paper, the paper reflects most of the light back in all directions, resulting in a strong reflected beam.

On the other hand, when light from a torch falls on a black polished mica sheet, the sheet absorbs most of the light and reflects very little, resulting in a weak reflected beam.

Therefore, the white sheet of paper will produce a stronger reflected beam than the black polished mica sheet.

139. Figure shows a concave mirror with its pole at P, focus F and centre of curvature C. Draw ray diagram to show the formation of image of an object OA.

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Convex mirrors prominently feature outwardly bulging reflecting surfaces that successfully diverge incident light. This unique geometric property guarantees a vastly expanded visual field of view, making them exceptionally ideal and popular choices for essential rearward monitoring in modern motor vehicles.

87. Automobile manufacturers specifically position tiny headlight bulbs exactly at the principal focus of polished concave reflectors to successfully achieve which geometric optical result?
(A) To generate completely diverging light rays illuminating nearby peripheral surroundings.
(B) To forcefully create highly concentrated, strictly parallel beams providing distant forward illumination.
(C) To purposely form inverted, massively enlarged real images directly upon the roadway.
(D) To continuously reflect incident rays strictly backward toward the vehicle's engine compartment.

Ans : (B)

Placing a tiny light bulb exactly at the principal focus of a polished concave reflector guarantees that completely diverging light rays actively reflect into a highly concentrated, strictly parallel beam, providing exceptionally strong and distant forward automotive roadway night-time illumination.

88. In a spherical mirror calculation, a computed linear magnification perfectly equating to precisely negative one strictly signifies which exact physical geometric scenario?
(A) A completely real, entirely inverted image forming exactly at the mirror's pole.
(B) A distinctly virtual, completely erect image possessing exactly half the object's height.
(C) A distinctly real, entirely inverted image forming precisely at the centre of curvature.
(D) A distinctly real, magnified image actively forming securely at the principal focus.

Ans : (C)

A computed linear magnification equating precisely to negative one signifies that a distinctly real, entirely inverted image possesses the exact same physical height as the original object. This perfectly balanced geometric scenario strictly occurs at the mirror's centre of curvature.

89. How can a student accurately project a bright, uniformly sized circular luminous light patch onto an experimental screen using a simple point source and a concave mirror?
(A) By deliberately placing the small point source precisely at the mirror's geometric pole.
(B) By securely placing the small point source exactly at the mirror's principal focus.
(C) By positioning the small point source strictly beyond the mirror's centre of curvature.
(D) By continuously placing the small point source directly upon the mirror's upper outer boundary.

Ans : (B)

Placing a small point source of light precisely at the principal focus of a completely concave mirror naturally forces all reflecting rays to emerge perfectly parallel. This specific arrangement effectively casts a consistently bright, identically sized circular luminous light patch.

ONE MARK QUESTIONS

90. What is the aperture of a spherical mirror ?

Ans :

The aperture of a spherical mirror is the diameter of its reflecting surface.

91. Define the pole of a spherical mirror.

Ans :

The pole is the geometric centre of the reflecting surface of the spherical mirror.

92. Select the luminous object (s) from the following: Sun, Moon, Earth, Shooting star, Fire

Ans :

The luminous objects from the following are: Sun and Fire and Shooting star.

93. What is a spherical mirror ?

Ans :

A mirror which is made from a part of a hollow sphere is called spherical mirror.

94. Define centre of curvature of a spherical mirror.

Ans :

The centre of curvature of a spherical mirror is the centre of the sphere of which the mirror is a part.

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95. Define radius of curvature of a spherical mirror.

Ans :

The radius of curvature of a spherical mirror is the distance between its pole and its centre of curvature..

96. State which surface of a plane mirror reflects most of the light incidence on it : the front smooth surface or the back silvered surface.

Ans :

Back silvered surface.

97. What do you mean by reflection of light ?

Ans :

When a beam of light is incident on a surface, a part of it returns into the same medium.
The phenomenon of returning of light into the same medium after striking a surface is called reflection.

98. For a ray reflected on a plane mirror, find the ratio of $\frac{\sin i}{\sin r}$.

Ans :

For reflection from a plane mirror, the law of reflection states that the angle of incidence equals the angle of reflection:
In other words, $\frac{\sin i}{\sin r} = 1$,

Where i is the angle of incidence and r is the angle of reflection.

99. The letters on the front of an ambulance are written laterally inverted like 331IAJU8MA. Give reason.

Ans :

Due to Lateral Inversion to the driver of front (moving ahead) the Letters will appear as AMBULANCE and he will make clear the way.

100. State two uses of a plane mirrors.

Ans :

Two uses of plane mirror are :
(i) Plane mirrors are used in construction of reflecting periscope.
(ii) They are used as looking glass.

101. A light ray strikes a mirror and retraces its path. What is the angle of incidence and angle of reflection?

Ans :

If a light ray retraces its path, it means it is reflected back along the same line.
This happens only when the ray strikes the mirror normally (along the normal).

$$i=0, r=0$$

102. What relationship do the images formed by two inclined plane mirrors have for their location with respect to the object placed between them?

Ans :

The image lie on the circumference of a circle whose centre lies at the point of intersection of the two mirrors and whose radius is equal to the distance of the object from the point of intersection.

TWO MARKS QUESTIONS

103. (a) For what position of object, the image formed by a concave mirror is magnified and erect ?
(b) State whether the image in part (a) is real or virtual?

Ans :

(a) When the object is in between the principal focus and the pole of concave mirror.
(b) The image being erect is virtual.

104. State the kind of mirror used
(a) By a dentist,
(b) As a search — light reflector.

Ans :

(a) A dentist uses Concave mirror.
(b) Mirror used as a search-light - reflector .is Concave mirror.

105. State the two laws of reflection of light.

Ans :

Laws of reflection are as follows :
(a) The incident ray, the reflected ray and the normal ray at the point of incidence, lie in the same plane.
(b) The angle of incidence i is equal to the angle of reflection r i.e. $\angle i = \angle r$.

106. (a) State the position of object for which the image formed by a concave mirror is of same size.
(b) Write two more characteristics of the image.

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Ans :

(a) When object is at centre of curvature.
(b) Characteristics are :
  (i) The image formed is also at centre of curvature.
  (ii) Image is real.

107. State two uses of a concave mirror.

Ans :

Two uses of concave mirror are:
(i) Concave mirror is used as a reflector in head lights of cars and in search light. The source of light (bulb) is placed at the principal focus and the reflector forms parallel beam of light.
(ii) For doctors to examine throat, ear, nose and eyes, light is focused with the help of concave mirror.

108. (a) What is a real image ?
(b) What type of mirror can be used to obtain a real image of an object ?
(c) Does the mirror mentioned in part (b) form real image for all locations of the object ?

Ans :

(a) When rays of light after reflection or refraction actually meet at some other point the image is real.
(b) Concave mirror.
(c) No, this mirror does not give real image of the object that lies between principal focus and pole.

109. How will you distinguish between a plane mirror, a concave mirror and a convex mirror, without touching them?

Ans :

Hold a pen in front of the mirror.
(i) If image is diminished and erect,it is convex.
(ii) If image is of the same size and size remains same on moving the mirror, it is plane mirror.
(iii) If image is upright, inverted and magnified, it is concave mirror.

110. Name the kind of mirror used to obtain : a real and enlarged image.
(a) a virtual and enlarged image.
(b) a virtual and enlarged image.
(c) a virtual and diminished image.
(d) a real and diminished image.

Ans :

(a) CONCAVE
(b) CONCAVE
(c) CONVEX
(d) CONCAVE

111. Two plane mirrors are placed making an angle θ in between them. Write an expression for the number of images formed if an object is placed in between the mirrors. State the condition, if any?

Ans :

When the two mirrors are kept perpendicular to each other, i.e., $\theta = 90°$, then for an object placed in between the two mirrors, the number of images formed will be

$$n = \frac{360^\circ}{\theta^\circ} - 1$$

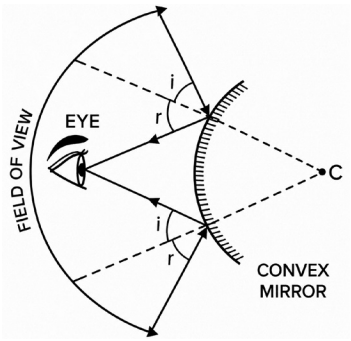
$$= \frac{360^\circ}{90^\circ} - 1 = 3.$$

Here n is an odd integer

112. Which mirror will you prefer to use as a rear view mirror in a car plane mirror or convex mirror ? Give one reason.

Ans :

A convex mirror will be preferred as a rear view mirror in a truck. The reason is that a convex mirror always forms a small and upright image between pole and focus. That means in a small area of mirror driver can see all the traffic coming from behind.



113. How is magnification (m) related to the distance of the object (u) and the distance of the image (v)?

Ans :

Magnification (m) is a measure of how much larger or smaller an image appears compared to the actual object. It is defined as the ratio of the height (or size) of the image to the height (or size) of the object.
In terms of the distance of the object (u) and the

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distance of the image (v), magnification (m) can be expressed as:

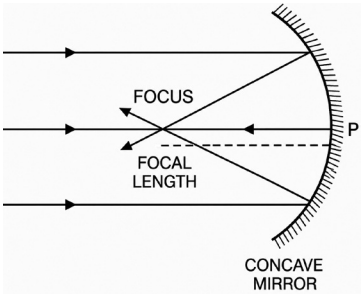
$$m = \frac{v}{u}$$

where v is the distance of the image and u is the distance of the object from the mirror or lens.

114. Define the terms focus and focal length of a concave mirror. Draw diagram to illustrate your answer.

Ans :

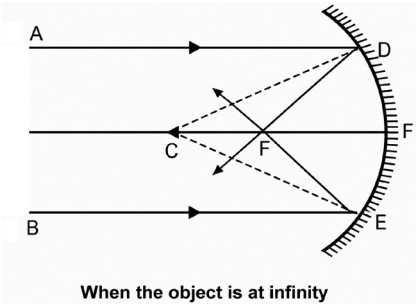
Focus (F) is a point on the principal axis where the rays parallel to principal axis after reflection actually meet.



Focal length is the distance between pole (P) and focus (F).

115. Upto what maximum distance from the pole the image in a convex mirror can be obtained ? What will be the location of object then ?

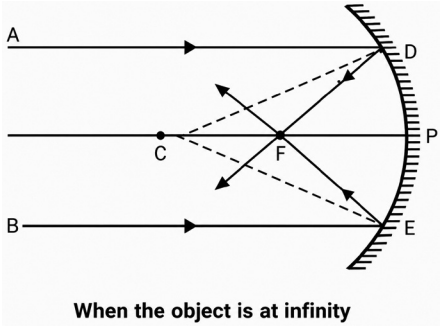
Ans :



The maximum distance at which the image in a convex mirror can be obtained is focal length. The location of the object will be infinity.

116. Upto what maximum distance from a concave mirror, the image can be obtained ? What will be the location of object for it ?

Ans :



The image can be obtained from infinity and the location of object is focus.

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THREE MARKS QUESTIONS

117. State the two convenient rays that are chosen to construct the image by a spherical mirror for a given object ? Explain your answer with the help of suitable ray diagrams.

Ans :

Two convenient rays choose to construct the image by a spherical mirror are :

(i) A ray parallel to the principal axis which after reflection passes or appears to pass through focus.

(ii) A ray passing through the centre of curvature or appears to pass through centre of curvature which retraces its path after reflection.

118. Write three characteristics of the image formed by a plane mirror ?

Ans :

Characteristics of Image formed by a Plane Mirror.

(i) Image is of the same size as that of object.

(ii) Image is laterally inverted.

(iii) It is upright.

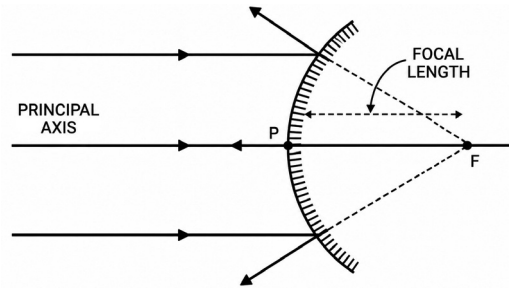
(iv) It is virtual.

(v) Image formed is as far behind the mirror as the object in front of the mirror.

119. Explain the meaning of the terms focus and focal length in case of a convex mirror, with the help of suitable ray diagrams.

Ans :

Focal length is the distance between pole (P) and focus (F).



(F) Focus is a paint on principal axis where rays of light appear to meet.

120. Differentiate between a real and a virtual image.

Ans :

The difference between a real and a virtual image are as follows :

	Real Image	**Virtual image**
1.	Can be taken on the screen.	Cannot be taken on screen.
2.	It is inverted.	It is erect.
3.	It is formed when light rays after reflection (or refraction) actually meet.	It is formed when rays of light after reflection (or refraction) appear to meet.

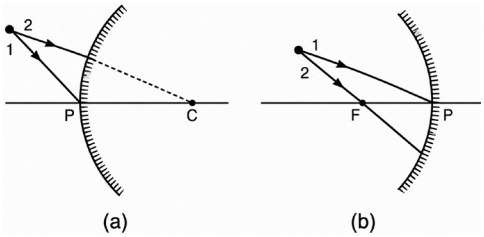
121. Discuss the position and nature of image formed by a convex mirror when an object is moved from infinity towards the pole of mirror.

Ans :

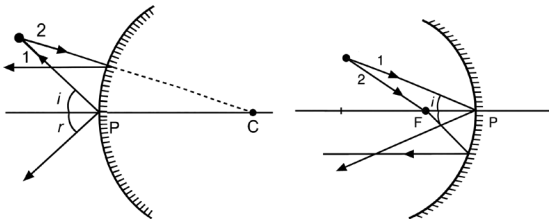
(1) When the object is at infinity in front of convex mirror, its image is formed behind the mirror at focus (F). It is of point size upright and virtual.

(2) As the object moves towards the mirror the distance of image from behind the mirror between pole and focus decreases i.e. shifts from focus towards pole and size of image increases, but remains upright, virtual and diminished.

122. Complete the following diagrams in Fig. by drawing the reflected rays for the incident ray 1 and 2.



Ans :



123. What is the most common use of a plane mirror ?

Ans :

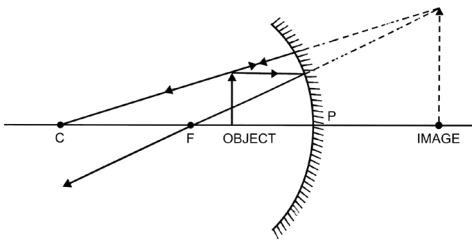
The most common use of a plane mirror is to reflect light and form images.

Plane mirrors are used in a wide variety of applications, including personal grooming (such as mirrors in bathrooms and dressing rooms), scientific experiments, and optical systems (such as telescopes and cameras). One of the main advantages of plane mirrors is that they produce a virtual image that is the same size as the object being reflected. This makes them useful in a range of optical systems and devices.

Additionally, plane mirrors are relatively simple and inexpensive to produce, making them a popular choice for many applications.

124. Draw a ray diagram to show the formation of image by a concave mirror for an object placed between its pole and focus. State three characteristics of the image.

Ans :



Characteristics of image formed :

(i) It is erect.

(ii) Image is magnified.

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the mirror's pole. Objects invariably reside on the left side, guaranteeing that initial incident light continually travels from left to right, thereby establishing definitive positive and negative measurement directions.

82. In optical physics, a real image genuinely materializes and becomes visible on a screen precisely because:
(A) Reflected light rays actively diverge immediately away from the principal axis.
(B) Reflected light rays completely retrace their original paths backwards toward infinity.
(C) Reflected light rays actually converge and physically intersect at a specific location.
(D) Reflected light rays only appear to intersect securely behind the reflecting surface.

Ans : (C)

Real images genuinely materialize precisely when reflected light rays actually converge and intersect at a specific physical location. Because these focal points exist securely in front of a concave mirror, such distinctly visible images invariably appear completely inverted geometrically downward.

83. An object is placed between two inclined plane mirrors. The number of images formed depends on the angle between the mirrors and sometimes on the object's position (symmetrical or asymmetrical).

Case	Angle (q)	n = 360°/q
1	90°	4
2	60°	6
3	50°	7.2
4	72°	5

In which case will the number of images formed depend on whether the object is placed symmetrically on the angle bisector or asymmetrically?
(A) Case 1
(B) Case 2
(C) Case 3
(D) Case 4

Ans : (D)

The rule for the number of images depending on symmetrical or asymmetrical placement applies only when $n = 360°/\theta$ is an odd integer. In Case 4, $n = 360°/72° = 5$, which is an odd integer. In this situation, (n-1) images are formed for symmetrical placement and 'n' images for asymmetrical placement.

84. Identify the completely accurate statement regarding the principal focus geometrically established by distinct types of spherical mirrors.
(A) Both concave and convex mirrors actively form entirely real focal points.
(B) A convex mirror establishes a real focus directly in front of its surface.
(C) A concave mirror establishes a real focus located straightforwardly in front of its surface.
(D) Both concave and convex mirrors uniformly form entirely virtual focal points.

Ans : (C)

A concave mirror physically converges incoming parallel light rays, effectively establishing a strictly real principal focus located straightforwardly in front. In contrast, a convex mirror actively diverges rays, uniquely forming a virtual focus hidden securely behind its polished reflecting surface.

85. An optical object is geometrically positioned exactly 20 cm from a concave mirror, and its completely real image manifests precisely at the exact same location. What is the calculated focal length?
(A) 40 cm
(B) 20 cm
(C) 10 cm
(D) 5 cm

Ans : (C)

Whenever a completely real image geometrically manifests at the exact same location as the physical object, both must reside precisely at the centre of curvature. Consequently, the focal length directly calculates as exactly half of this measured horizontal object distance.

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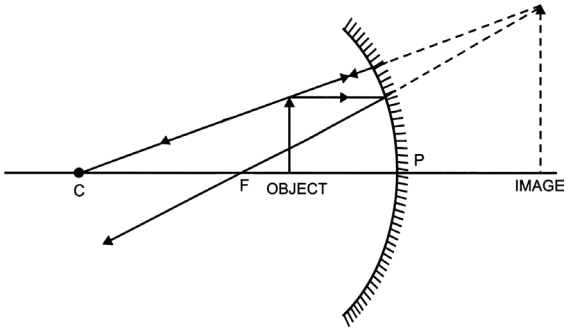
86. Which specific geometric property natively guarantees that convex mirrors remain exceptionally ideal and popular choices for essential rearward monitoring in modern automobiles?
(A) They consistently produce highly magnified, completely inverted virtual images.
(B) Their outwardly bulging reflecting surfaces successfully diverge light, creating a vastly expanded field of view.
(C) They actively converge incoming parallel light strictly onto a singular intense focal point.
(D) They uniformly form completely real images strictly regardless of the physical object's distance.

Ans : (B)

Characteristics of image formed are :
(i) Image is virtual.
(ii) Image is erect.
(iii) Image is diminished.

130. Draw a ray diagram to show the formation of image by a concave mirror for the object beyond its centre of curvature. State three characteristics of the image.

Ans :

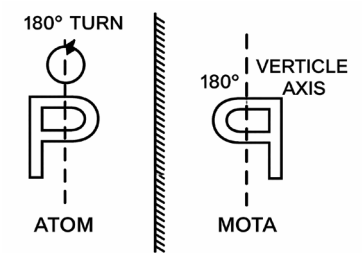


Characteristics of image formed :
(i) It is real.
(ii) It is inverted.
(iii) It is diminished.

131. What is meant by lateral inversion of an image in a plane mirror ? Explain it with the help of a ray diagram.

Ans :

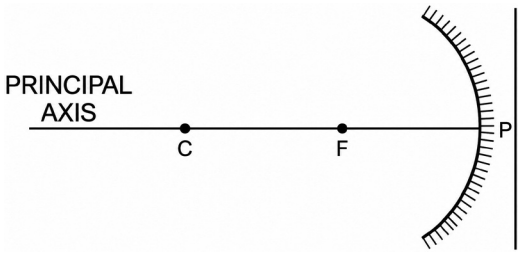
The phenomenon due to which the image of an object turns through an angle of 180° through verticle axis rather the horizontal axis, such that right side of image appears as left or vice-versa is called Lateral Inversion. During lateral inversion the left side of object appears as right side of image and vice-versa. In a way the image turns through the angle of 180° about vertical axis.



132. Define the terms pole,principal axis and centre of curvature with reference to a spherical mirror.

Ans :

Principal axis :An imaginary line passing through the pole and the centre of curvature of a spherical mirror is called principal axis.



Centre of curvature : It is the centre of hollow sphere of which the mirror forms a part. It is denoted by C.
Pole : It is the mid-point of the mirror. It is denoted by P.

133. Discuss the position and nature of image formed by a concave mirror when an object is moved from infinity towards the pole of mirror.

Ans :

(1) In a concave mirror, when object is at infinity its image is formed at focus (F) in front of mirror. It is real, diminished and inverted.
We know that when object is at C i.e. at 2 F the image formed is of equal size and at 2f.
(2) As object moves towards mirror, the image grows in size and moves away from mirror towards centre of curvature, till at C the image is of same size as of object.
On moving towards mirror the image still moves away beyond C and when object is at F, the image formed is at infinity. When object moves towards pole of mirror, the image now becomes erect and magnified and is formed behind the mirror is virtual.

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134. Why does a driver use a convex mirror instead of a plane mirror as a rear view mirror ? Illustrate your answer with the help of a ray diagram.

Ans :

A convex mirror always forms a small and upright image between pole and focus. That means in small area of mirror driver can see all the traffic coming from behind.

(iii) Image is virtual.
(iv) It is upright.

125. Write the spherical mirror's formula and explain the meaning of each symbol used in it.

Ans :

The spherical mirror formula is written below :

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Where f is focal length, u is the distance of object and v is the distance of image.
In the above relation, the values of known quantities out of u, v and f are substituted with their proper sign.
For concave mirror :
(i) For real image : Values of u, v and f are always negative.
(ii) For virtual image : Values of u and f are always negative but v is positive.
For convex mirror : Values of u is always negative and the values of v and f are always positive.

126. Differentiate between the reflection of light from a plane mirror and that from a wall.

Ans :

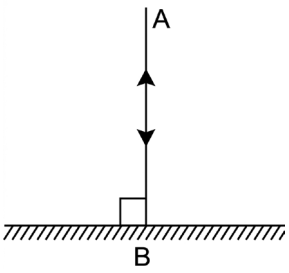
The difference between reflection of the light from the plane mirror and from the wall are as follows :

	Reflection of light from a plane mirror	**Reflection of light from a wall**
1.	It is a regular reflection.	It is a irregular reflection.
2.	Light rays falls on a smooth and polished surface, a parallel beam of light is incident on a plane mirror, the reflected beam is also parallel.	Light rays strike at different parts of a rough surface, each ray gets reflected from different points of the rough surface in different direction.

127. A light ray is incident normally on a plane mirror
(a) What is its angle of incidence ?
(b) What is the direction of the reflected ray ? Show it on a diagram.

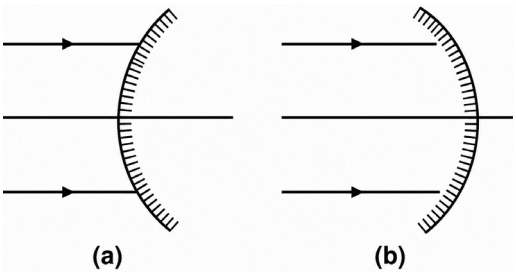
Ans :

(a) Angle of incidence is 0°.

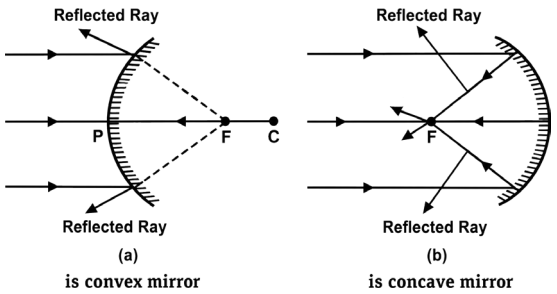


(b) Since angle of incidence is the angle between incident ray and normal. Direction of reflected ray is along BA opposite to the direction of incident ray.

128. Name the mirrors shown in Fig. (a) and (b). (ii) In each case (a) and (b), draw the reflected rays for the given incident rays and marks the focus by the symbol F.

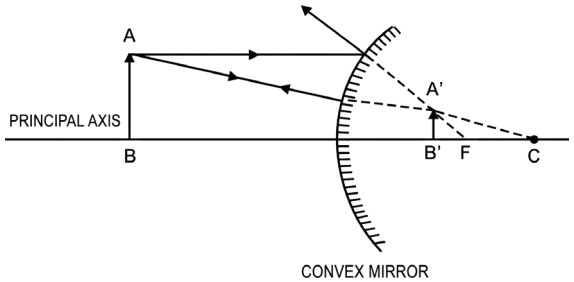


Ans :



129. Draw a ray diagram to show the formation of image of an object kept in front of a convex mirror. State three characteristics of the image.

Ans :



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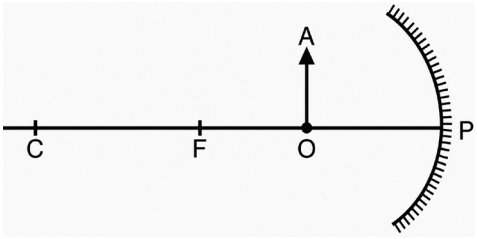
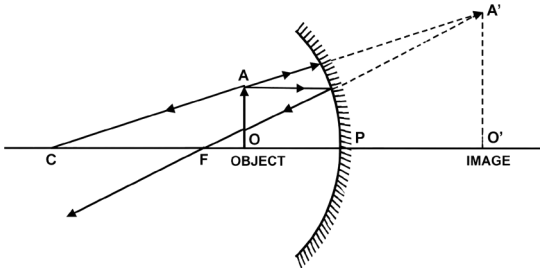


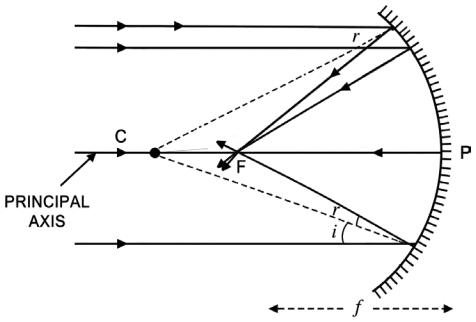
Ans :



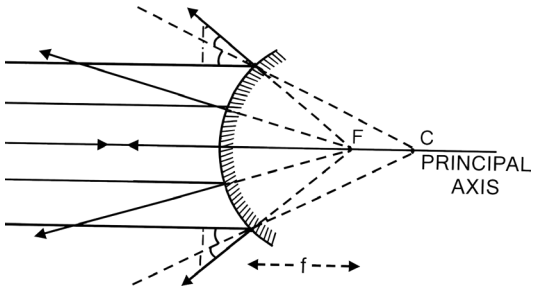
140. Draw suitable diagrams to illustrate the action of (i) concave mirror, and (ii) convex mirror, on a beam of light incident parallel to the principal axis.

Ans :

(i) Concave mirror

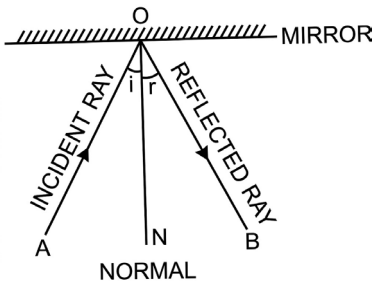


(ii) Convex mirror



141. Draw a diagram to show the reflection of a ray of light by a plane mirror. In the diagram, label the incident ray, the reflected ray, the normal, the angle of incidence and the angle of reflection.

Ans :



Where,

AO is the incident ray

OB is the reflected ray

ON is the normal

$\angle AON$ is the angle of incidence

$\angle NOB$ is the angle of reflection.

142. How does an optician increase the effective length of his room by using a mirror ? Where does he place the sign board ?

Ans :

An optician can increase the effective length of his room by using a mirror by creating an illusion of depth.

To achieve this, the optician can place a large mirror at the end of the room, opposite to the entrance. The mirror will reflect the image of the room and make it appear as if it extends further than it actually does.

By using this technique, the optician can create an impression of a larger space, making the room feel more open and inviting. This can be especially useful in smaller rooms or shops where space is limited.

The optician can place the signboard either on the wall opposite to the mirror or on the same wall as the mirror, slightly to the side. The key is to ensure that the signboard is clearly visible from the entrance and does not obstruct the reflection of the room in the mirror.

143. Name the spherical mirror which (i) diverges (ii) converges the beam of light incident on it. Justify your answer by drawing a ray diagram in each case.

Ans :

(i) A spherical mirror which diverges the beam of light incident on it is called convex mirror.

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$$\frac{1}{3} = -\frac{v}{u}$$

$$\frac{1}{3}u = -v$$

$$v = -\frac{1}{3}u$$

165. An optician while testing the eyes of a patient keeps a chart of letter 3 m behind the patient and asks him to see the letters on the image of chart formed in a plane mirror kept at distance 2 m in front of him. At what distance is the chart seen by the patient ?

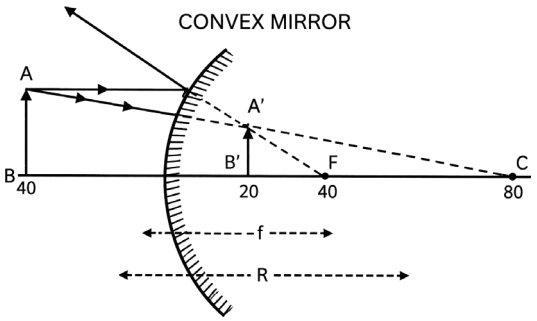
Ans :

Initially the distance between letters and patient = 3m
Distance of patient from plane mirror = 2m
Distance of image formed in the mirror = 2m
(Distance of image in a plane mirror is as far behind the mirror as the object is in-front of it.)
Distance between chart and patient = 3 + 2 + 2 = 7m

166. A point light source is kept in front of a convex mirror at a distance of 40 cm. The focal length of the mirror is 40 cm. Find the position of image.

Ans :

Since the object lies at 40 cm in front of mirror and focal length is also 40 cm.



Object lies at F in front of convex mirror.
Image is formed at 20 cm behind the mirror.

167. A ray is incident on a plane mirror. Its reflected ray is perpendicular to the incident ray. Find the angle of incidence.

Ans :

$$\angle i = \angle r = x^\circ \qquad \text{(say) Laws of Reflection}$$

$$\angle i + \angle r = 90^\circ \qquad \text{(given)}$$

$$x^\circ + x^\circ = 90^\circ$$

$$2x = 90^\circ$$

$$x = \frac{90}{2} = 45^\circ$$

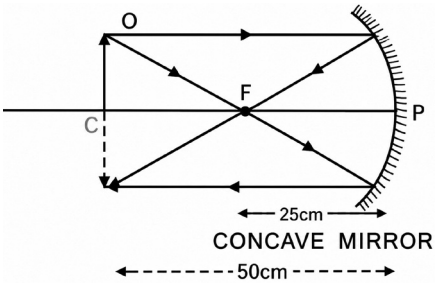
$$\angle i = 45^\circ$$

168. At what distance from a concave mirror of focal length 25 cm should an object be placed so that the size of image is equal to the size of the object.

Ans :

Given $f = 25\text{cm}$, $u = ?$
Size of image is equal to size of object.
The object must be placed at C
i.e. at $2f = 2 \times 25$

$= 50\,\text{cm}$



169. An object is placed (i) asymmetrically (ii) symmetrically, between two plane mirrors inclined at an angle of 50°. Find the number of images formed.

Ans :

(i) Number of images formed when two plane mirrors are placed asymmetrically at angle 0 is given by

$$n = \frac{360^\circ}{\theta^\circ} - 1$$

$$= \frac{360^\circ}{50^\circ} = 7.2 \approx 7$$

(ii) Number of images formed when two plane mirrors are placed symmetrically

$$= n - 1$$

$$= 7 - 1 = 6$$

170. An object is kept at 60 cm in front of a plane mirror. If the mirror is now moved 25 cm away from the object, how does the image shift from its previous position ?
Ans,

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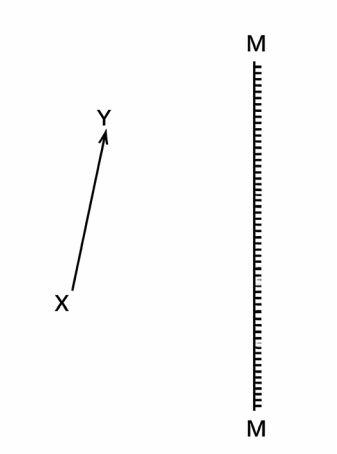
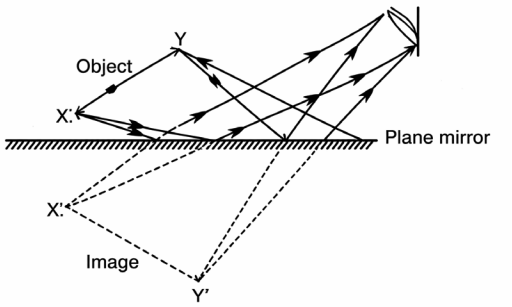
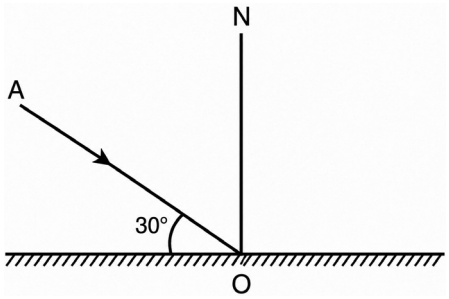


Ans :



148. Fig. shows an incident ray AO and the normal ON on a plane mirror. The angle which the incidence ray OA makes with the mirror is 30°.



(a) Find the angle of incidence.

(b) Draw the reflected ray and then find the angle between the incident and reflected rays.

Ans :

ON is perpendicular on a plane mirror

Angle of incidence $\angle i (\angle \text{AON})$ i.e.

Angle between incident ray and normal ray

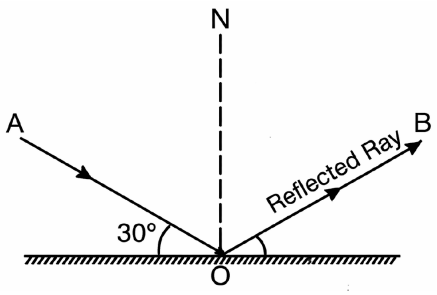
$$= 90^\circ - 30^\circ = 60^\circ$$

Angle of Reflection $= 60^\circ$

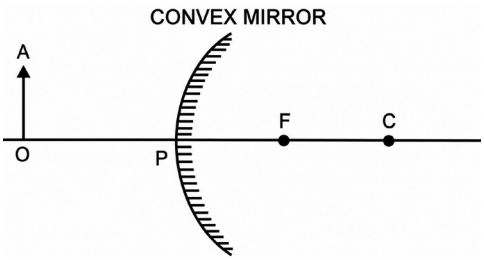
$$\angle i = \angle r$$

Angle between incident and reflected ray i.e. $\angle$AOB

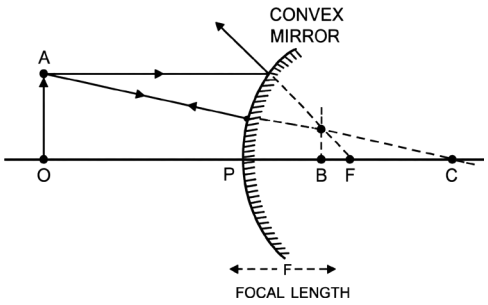
$$= 60 + 60 = 120^\circ$$



149. The diagram below in Fig. shows a convex mirror. C is its centre of curvature and F is its focus. (i) Draw two rays from A and hence locate the position of the image of object OA. Label the image IB. (ii) State three characteristics of the image.



Ans :



(i) Distance $FP = 1.35$

(ii) Three characteristics of image.

(1) Image is virtual.

(2) Image is upright.

(iii) Image is diminished.

150. The diagram in fig. shows a point object P in front of a plane mirror MM_1. (a) Complete the diagram by taking two rays from the point P to show the formation of its image. (b) In the diagram, mark the position of eye to see the image. (c) Is the

(a) Where will the image form ?

(b) What will be the length of image ?

Ans :

Given,

$$f = 15 \text{ cm}$$

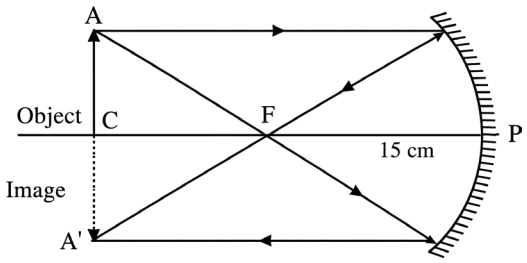
$$R = 2f$$

$$= 2 \times 15$$

$$= 30 \text{ cm}$$

As object is placed at C

(a) Image is also formed at C.



(b) On measurement, we find that PB' = 30 cm.

The image is formed at a distance of 30 cm in front of the mirror.

Size of the image $= A'B' = 4$ cm

Nature of the image : Real, inverted and equal to the size of object.

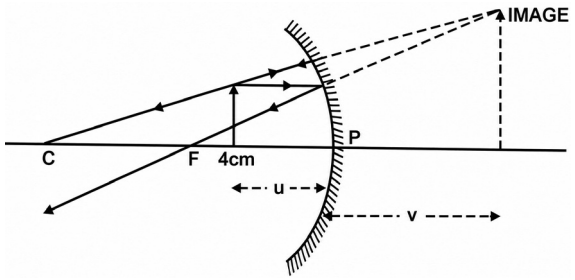
175. When an object of height 1 cm is kept at a distance 4 cm from a concave mirror, its erect image of height 1.5 cm is formed at a distance 6 cm behind the mirror. Find the focal length of mirror.

Ans :

$$\text{O} = 1 \text{ cm}$$

$$\text{I} = 1.5$$

$$= \frac{3}{2} \text{ cm}$$



$$u = -4 \text{ cm}$$

$$v = 6 \text{ cm}$$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{f} = \frac{-1}{4} + \frac{1}{6}$$

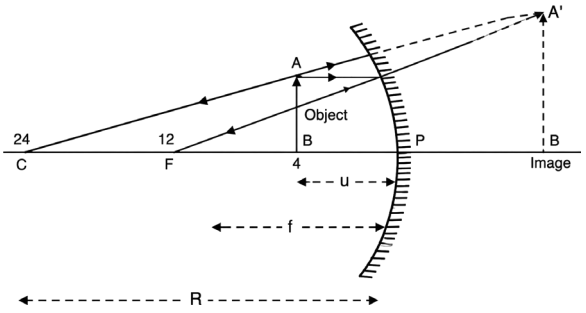
$$= \frac{-1}{12}$$

$$\text{f} = -12 \text{ cm}$$

Focal length of concave mirror = 12 cm.

176. An object is placed at 4 cm distance in front of a concave mirror of radius of curvature 24 cm. Find the position of image. Is the image magnified ?

Ans :



$$u = -4 \text{ cm}$$

$$\text{R} = 24 \text{ cm}$$

$$\text{f} = \frac{R}{2}$$

$$= \frac{24}{2}$$

$$= 12 \text{ cm}$$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$= \frac{1}{-12} - \frac{1}{-4}$$

$$= \frac{-1}{12} + \frac{1}{4}$$

$$= \frac{-1+3}{12}$$

$$\text{v} = 6 \text{ cm}$$

Yes, the image is magnified.

177. An object 5 cm high is placed at a distance 60 cm in front of a concave mirror of focal length 10 cm. Find (i) the position and (ii) size of the image.

Ans :

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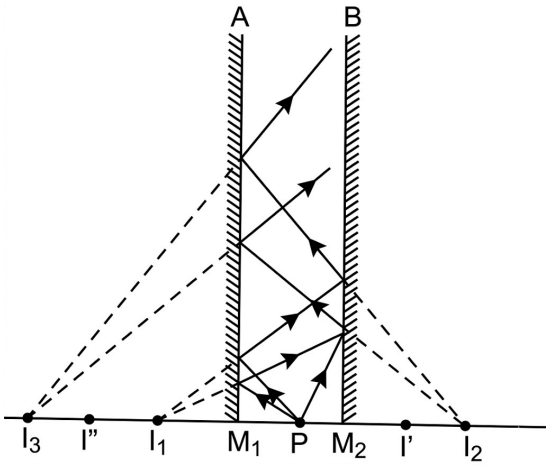
153. Two plane mirrors are arranged parallel and facing each other at some separation. How many images are formed for a point object kept in between them? Show the formation of images with the help of a ray diagram.

Ans :

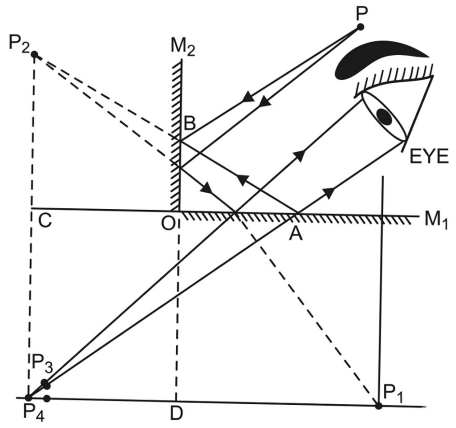
Two parallel mirrors AM_1 and BM_2, object P is placed between them (1) image formed I_1 formed by reflection from AM_1 and by reflection from BM_2 is I' not shown. Now I_1 acts as virtual object for mirror BM_2 and image I_2 is formed. And so on a number of images are formed. The intensity of the remote images goes on decreasing since at each reflection, some light is absorbed and we can see a few images.



154. How many images are formed for a point object kept in between the two plane mirrors at right angles to each other ? Show them by drawing a ray diagram.

Ans :

Number of images formed When kept in between two plane mirrors at right angles to each other are :



$$n = \frac{360}{\theta} - 1$$

$$n = \frac{360}{90} - 1$$

$$n = 4 - 1$$

$$n = 3$$

155. State the laws of reflection and describe an experiment to verify them.

Ans :

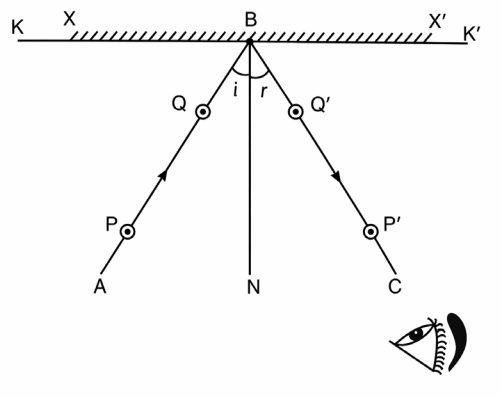
Laws of reflection are as follows :

(i) The incident ray, the reflected ray and the normal at the point of incidence, lie in the same plane.

(ii) The angle of incidence and angle of reflection are equal i.e. $\angle i = \angle r$.

Verification of the Law of the Reflection :

Take a wooden drawing board and fix a white sheet of paper on it. In the middle of paper draw a straight line KK'. Mark a point B on it. Draw a perpendicular BN. Place a mirror XX' on line KK' such that polished side of mirror is along the line. Hold the mirror in the mirror holder.



Fix two steel pins P and Q on the straight line AB at least 10 cm apart. Look for the images of the pins P and Q and fix two pins ?, Q such that P', Q' and images of P and Q are all in the same straight line. Remove the pins and draw small circles around the pin pricks.

Remove the mirror also. Join P' Q' and produce the straight line to meet at B.

Measure $\angle ABN = i$ and $\angle CBN = r$.

It is found that $\angle i = \angle r$.This proves that Angle of Incidence is equal to Angle of Reflection.

As the incident ray, the reflected ray and the normal lie in the plane of paper, therefore, they lie in the same plane.

156. Explain the following terms :-

(a) plane mirror,

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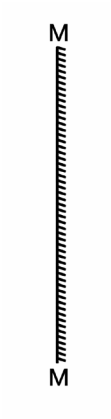
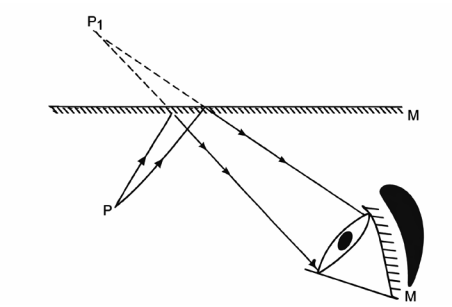
image formed real or virtual? Explain why?



Ans :

(a) and (b)



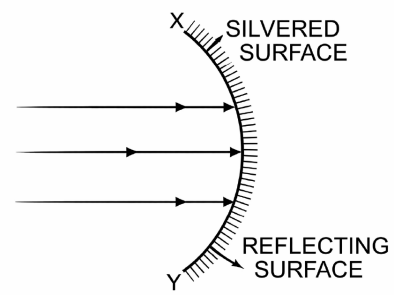
(c) Image is virtual, because image formed in a plane mirror is virtual as the rays after reflection appear to meet at P1.

151. Name the two kinds of spherical mirrors and distinguish between them.

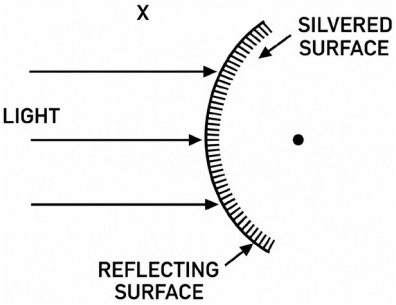
Ans :

Spherical mirrors are of two kinds which are as follows:

(i) Concave mirror :A mirror made by silvering the outer or the bulging surface such that the reflection takes place from the concave surface. Centre of curvature is towards the reflecting surface.



(ii) Convex mirror : A mirror made by silvering the inner surface such that reflection takes place from the bulging surface is called convex mirror.



Centre of curvature is towards the silvered surface.

FOUR MARKS QUESTIONS

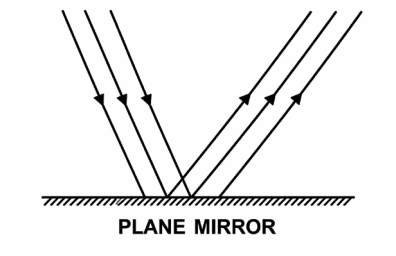
152. With the help of diagrams, explain the difference between the regular and irregular reflection.

Ans :

Regular reflection :

(i) Parallel beam of light falls on a smooth, polished surface.

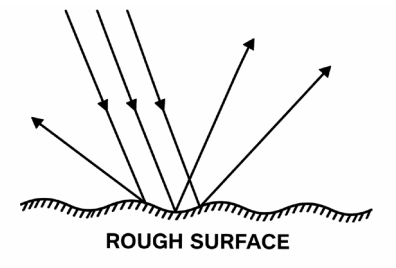
(ii) Rays after reflection are parallel.



Irregular reflection :

(i) Parallel beam of light falls on rough or unpolished surface.

(ii) Reflected rays are not parallel.



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and $\angle NDR = \angle CDF$

(vertically opposite angles

Hence $\angle FCD = \angle CDF$

ΔFDC is isosceles. Hence, $DF = FC$

If the aperture of the mirror is small, the point D is very close to the point P. Then $DF = PF$.

$$PF = FC$$

or $$PF + PF = PF + FC$$

$$2PF = PC$$

$$\text{PF} = \frac{1}{2}PC$$

$$f = \frac{1}{2}R$$

Thus, for a spherical mirror (both concave and convex), focal length is half of its radius of curvature.

NUMERICAL QUESTIONS

158. The focal length of a concave mirror is 10 cm. Find its radius of curvature.

Ans :

Focal length $f = 10\,\text{cm}$

$$\text{R} = 2\text{f}$$

$$= 2 \times 10 = 20\,\text{cm}$$

159. The radius of curvature of a convex mirror is 40 cm. Find its focal length.

Ans :

Given,

Radius of curvature $R = 40$ cm

$$\text{Focal length} = \frac{R}{2} = \frac{40}{2} = 20\,\text{cm}$$

160. A man standing in front of a plane mirror finds his image at a distance 6 metre from himself. What is the distance of man from the mirror ?

Ans :

Since image formed in a plane mirror is as far behind the mirror as the object is infront of it i.e. distance of object from mirror = distance of image from mirror

Distance of man from mirror $= \frac{6}{2} = 3 = 3\text{m}$

161. The erect image formed by a concave mirrors is of size double the size of object. How are u and v related ?

Ans :

Given, $m = 2$

Since, magnification *'m'* is positive,

It's virtual image and hence u is '+ ve'

$$m = -\frac{v}{u}$$

$$2 = -\frac{v}{u}$$

$$v = -2u$$

162. The magnification for a mirror is -3. How are u and v related?

Ans :

Given, $m = -3$

As we know that

$$m = \frac{v}{u}$$

$$-3u = v$$

$$v = -3u$$

163. An insect is sitting in front of a plane mirror at a distance 1 m from it.

(a) Where is the image of the insect formed ?

(b) What is the distance between the insect and its image ?

Ans :

Here distance of insect in front of a plane mirror = 1 m

(a) Distance of image from mirror =1m. Distance of image in a plane mirror is as far behind the mirror as the object is in-front of it.

(b) Distance between insect and its image = 1 + 1 = 2m.

164. The image formed by a convex mirror is of size one - third the size of object. How are u and v related ?

Ans :

Given, $m = \frac{1}{3}$

Since, magnification n is positive

It's virtual image

$$m = -\frac{v}{u}$$

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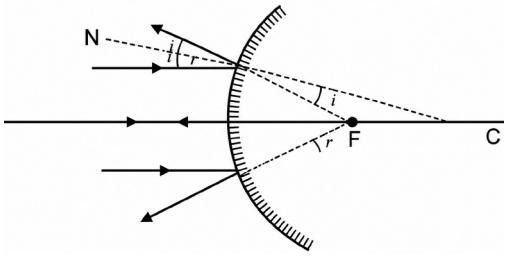
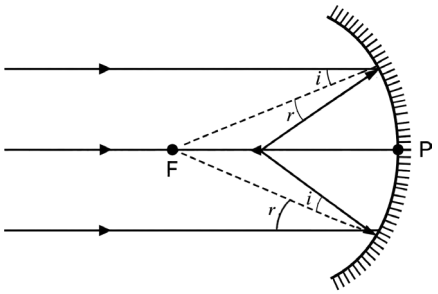


(ii) Concave mirror is used to converge a beam of light.



Rays parallel to the principal axis after reflection meet at F.

144. Two plane mirrors are placed making an angle 0° in between them. For an object placed in between the mirrors, if angle is gradually increased from 0° to 180°, how will the number of images change: increase, decrease or remain unchanged?

Ans :

If two plane mirrors are placed making an angle in between then, the number of images formed between the mirror will decrease. Examples : If the angle between two mirrors is 60°,

$$n = \frac{360^\circ}{60^\circ} = 6$$

The number of images is $(n-1) = 5$ ...(1)
5 images will be formed.
If the angle between two mirrors is 72°,

$$n = \frac{360^\circ}{72^\circ} = 5$$

The number of images in -$(n-1) = 5-1 = 4$ ...(2)
4 images will be formed
From (1) and (2), it is defined that the number of images formed between the mirrors will get decrease with increase in angle of two plane mirrors.

145. What is meant by magnification ? Write its expression. What is its sign for the (a) real (b) virtual image ?

Ans :

If the length of the object and image are measured perpendicular to the principal axis, the ratio of length of the image to the length of the object, is called linear magnification.
If length of the image is I and that of the object is O, then

$$\text{Magnification} = \frac{\text{Length of the image } (I)}{\text{Length of the object } (O)}$$

$$= \frac{\text{Distance of image } (v)}{\text{Distance of object } (u)}$$

$$\text{m} = \frac{I}{O} = -\frac{v}{u}$$

(a) Signs for real image : u and v both are negative, so the linear magnification is negative. A real image is always inverted.
(b) Signs for virtual image : u is negative while v is positive, so linear magnification is positive. A virtual image is always erect.

146. What is meant by magnification ? Write its expression. What is its sign for the (a) real (b) virtual image ?

Ans :

If the length of the object and image are measured perpendicular to the principal axis, the ratio of length of the image to the length of the object, is called linear magnification.
If length of the image is I and that of the object is O, then

$$\text{Magnification} = \frac{\text{Length of the image (I)}}{\text{Length of the object (O)}}$$

$$= \frac{\text{Distance of image } (v)}{\text{Distance of object } (u)}$$

or $$\text{m} = \frac{\text{I}}{\text{O}} = -\frac{v}{u}$$

(a) Signs for real image : u and v both are negative, so the linear magnification is negative. A real image is always inverted.
(b) Signs for virtual image : u is negative while v is positive, so linear magnification is positive. A virtual image is always erect.

147. The diagram below in figure, shows an object XY in front of a plane mirror MM_1. Draw on the diagram, path of two rays from each point X and Y of the object to show the formation of its image.

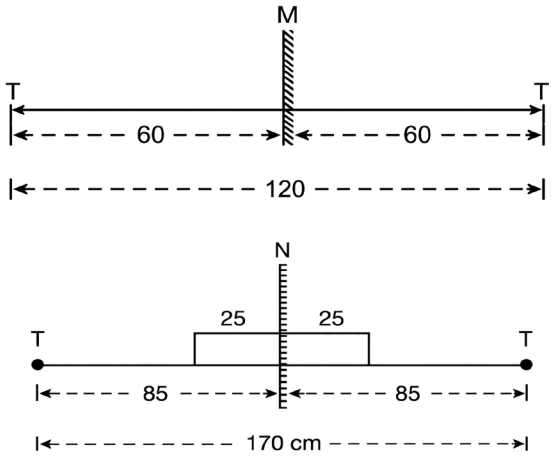


Image shifts from its previous position by $170 - 120 = 50$ cm

171. A concave mirror forms a real image of an object placed in front of it at a distance 30 cm, of size three times the size of object. Find
(a) the focal length of mirror
(b) position of image.

Ans :

(a) Given, di stance from the object $(u) = 30$ cm
Distance from the image $(v) = 90$ cm
Focal length = ?
We know,

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{f} = \frac{1}{-30} + \frac{1}{-90}$$

[Since, the formed image is real, u and v will be negative]

$$\frac{1}{f} = \frac{-3-1}{-90}$$

$$\frac{1}{f} = \frac{-4}{-90}$$

$$\frac{1}{f} = \frac{1}{22.5}$$

$$f = 22.5 \text{ cm}$$

Thus the focal length = 22.5 cm
(b) Position of the image shall be 90 cm
Position from image = 3 times distance from object
Position from image $= 3 \times 30 = 90$ cm

172. State the number of images of an object placed between the two plane mirrors, formed in each case when the mirrors are inclined to each other at (i) 90°, and (ii) 60°.

Ans :

(i) Numbers of images formed is given by the formula

$$n = \frac{360^\circ}{\theta^\circ} - 1$$

If two mirrors are at angle θ.

$$\theta = 90^\circ$$

$$n = \frac{360^\circ}{90^\circ} - 1$$

$$= 4 - 1$$

$$= 3$$

Number of images formed 3

(ii) $$\theta = 60^\circ$$

$$n = \frac{360^\circ}{60^\circ} - 1$$

$$= 6 - 1 = 5$$

Number of images formed is 5.

173. A concave mirror forms a virtual image of size twice that of the object placed at a distance 5 cm from it. Find : (a) the focal length of the mirror, (b) position of image.

Ans :

(a) Given,
Distance from the object $(u) = 5$ cm
Distance from the image $(v) = 10$ cm
Focal length = ?
We know,

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{f} = \frac{1}{-5} + \frac{1}{10}$$

[Since, the formed image is virtual, u will be negative]
be negative]

$$\frac{1}{f} = \frac{-2+1}{-10}$$

$$= \frac{-1}{-10}$$

$$\frac{1}{f} = \frac{1}{10}$$

$$f = 10 \text{ cm}$$

(b) Position of the image shall be 10 cm
Position from image = 2 times distance object
Position from image $= 2 \times 5 = 10$ cm

174. An object of length 4 cm is placed in front of a concave mirror at distance 30 cm. The focal length of mirror is 15 cm.

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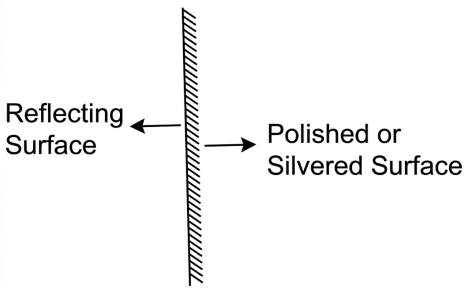
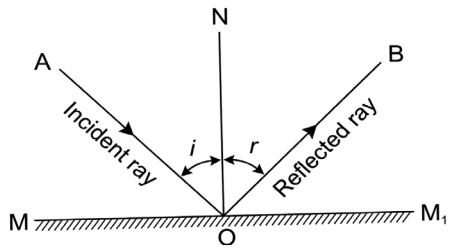
(b) incident ray,
(c) reflected ray,
(d) angle of incidence,
(e) angle of reflection.
Draw diagram/diagrams to show them.

Ans :

(a) A plane mirror is a highly polished and smooth surface which reflects almost the entire light falling on it. A plane mirror is made by silvering one side of a glass plate as shown in figure.



(b) Incident ray: The light ray striking a reflecting surface is called the incident ray.
(c) Reflected ray: The light ray obtained after reflection from the surface, in the same medium in which the incident ray is travelling, is called the reflected ray.
(d) Angle of incidence: The angle which the incident ray makes with the normal at the point of incidence is called the angle of incidence. It is denoted by the letter 'i'
(e) Angle of reflection : The angle which the reflected ray makes with the normal at point of incidence, is called the angle of reflection. It is denoted by the letter 'r'.



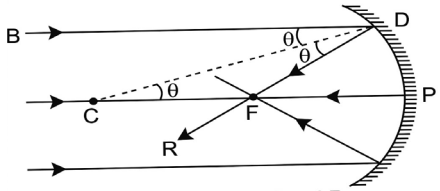
157. How is the focal length of a spherical mirror related to its radius of curvature ?

Ans :

The focal length of a spherical mirror is equal to half of its radius of curvature. i.e.

$$f = \frac{1}{2}\mathrm{R}$$

In figure (i) and figure (ii), P is the pole, C is the centre of curvature and F is the focus of the mirror. The distance PF is equal to the focal length f the distance PC is equal to the radius of curvature R of the mirror.
For concave mirror : In figure (i), a ray BD, parallel to the principal axis PC, is incident on the concave mirror PD. After reflection, it goes along DR passing through its focus F.



Relationship between *f* and R for a concave mirror

Then $\angle \mathrm{BDC} = \angle \mathrm{DCF}$ (alternate angles)

and $\angle \mathrm{BDC} = \angle \mathrm{CDF}$

(law of reflection, $\angle i = \angle r$)

Hence $\angle \mathrm{DCF} = \angle \mathrm{CDF}$

Δ FDC is isosceles. Hence DF = FC

If aperture of the mirror is small, the point D is very close to the point P, then DF = PF

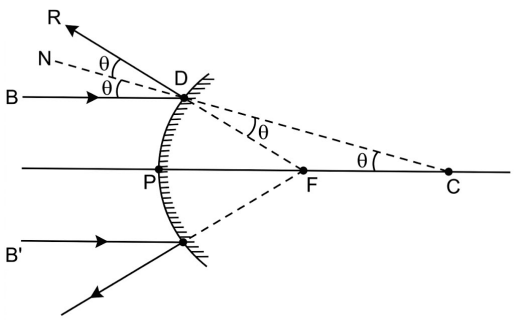
$$\mathrm{PF} = \mathrm{FC}$$

or $$\mathrm{PF} + \mathrm{PF} = \mathrm{PF} + \mathrm{FC}$$

or $$2\mathrm{PF} = \mathrm{PC}$$

or $$\mathrm{PF} = \frac{1}{2}\ \mathrm{PC} \text{ or } f = \frac{1}{2}\ \mathrm{R}$$

For convex mirror : In the figure (ii), a ray of light BD incident on the convex mirror, parallel to the principal axis PC, after reflection appears to come from its focus F. At the point of incidence D, the normal on mirror is DC.



Relationship between *f* and R for a convex mirror

Then $\angle BDN = \angle FCD$ (corresponding angles)

$\angle BDN = \angle NDR$ (law of reflection,

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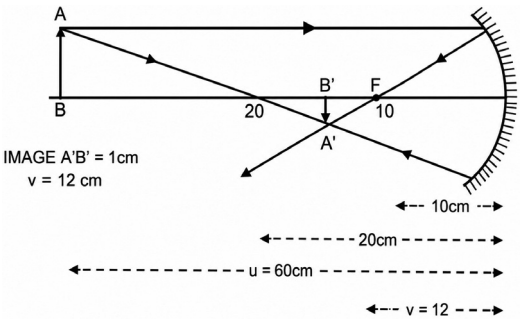


By drawing position of image between F and C size of image diminished.

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\frac{1}{v} = \frac{-1}{10} - \left(\frac{-1}{60}\right)$$

$$= \frac{-1}{10} + \frac{1}{60} = \frac{-1}{12}$$

$$\mathrm{V} = -12\,\mathrm{cm}$$

$$\mathrm{m} = \frac{I}{O} = \frac{-V}{u}$$

$$\frac{I}{5} = -\frac{-12}{-60}$$

$$= \frac{1}{5}$$

$$\mathrm{I} = 1\,\mathrm{cm}$$

178. An object of height 2 cm is placed at a distance 20 cm in front of a concave mirror of focal length 12 cm. Find the position, size and nature of the image.

Ans :

$$\mathrm{O} = 2\,\mathrm{CM},\ \mathrm{I} = ?$$

$$\mathrm{u} = -20\,\mathrm{CM}$$

$$\mathrm{f} = -12\,\mathrm{CM}$$

$$\frac{1}{V} = \frac{1}{f} - \frac{1}{u}$$

$$= -\frac{1}{12} - \left(\frac{-1}{20}\right)$$

$$= \frac{-1}{12} + \frac{1}{20}$$

$$= \frac{-5+3}{60}$$

$$\mathrm{V} = -30\,\mathrm{CM}$$

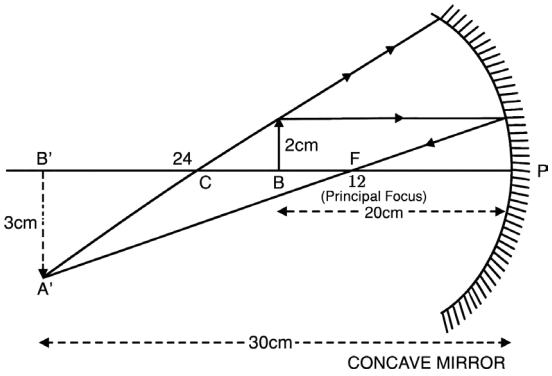
$$\frac{I}{O} = \frac{V}{u}$$

$$\frac{I}{2} = \frac{-30}{-20} = 1.5$$

$$I = 2 \times 1.5 = 3\,\mathrm{CM}$$

Nature of Image : Real, inverted, magnified.

Graphically



CASE BASED QUESTIONS

179. Anjali visits an eye clinic for a vision test. The room is relatively small, so the optician uses a specific mirror arrangement to increase the effective length of the room. A plane mirror is fixed on the wall directly in front of Anjali at a distance of 2 m from her chair. The optician places a vision chart on the wall exactly 3 m behind Anjali's chair. Anjali is asked to read the letters on the image of the chart formed in the plane mirror in front of her.

(a) Calculate the perpendicular distance of the vision chart from the plane mirror.

(b) Calculate the total distance between Anjali and the image of the chart she is seeing in the mirror.

Ans :

(a) Distance of chart from mirror = Distance of Anjali from mirror + Distance of chart behind Anjali

$$\text{Distance of chart} = 2m + 3m$$

$$\text{Distance of chart} = 5\,m.$$

(b) Total distance = Distance of Anjali from mirror + Distance of image from mirror

$$\text{Total distance} = 2m + 5m$$

$$\text{Total distance} = 7m.$$

180. Rahul visits a science museum and observes a room where two large plane mirrors are joined at one edge. He measures the angle between the two mirrors to be exactly 60°. He places a small

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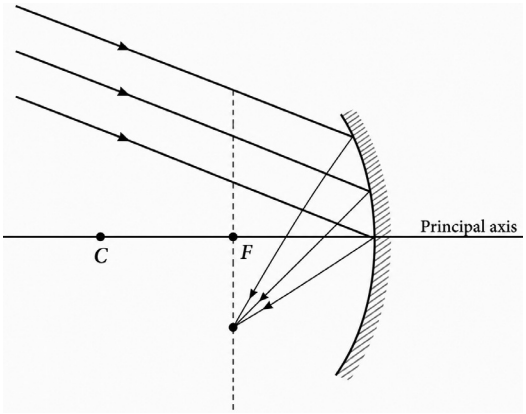
illustrates the reflection of these specific rays.



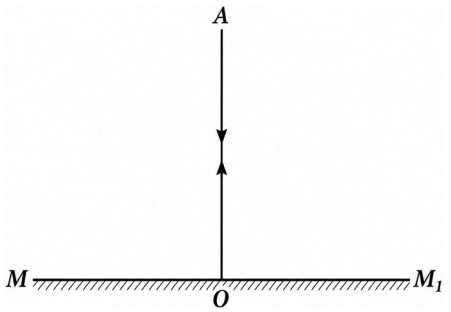
(a) Name the vertical dashed line passing through point F and state its relation to the principal axis.
(b) Identify the types of incident rays shown in the diagram based on their inclination, and state the position where the final image is formed.

Ans :

(a) 1. The vertical dashed line passing through the focus is scientifically termed as the focal plane of the mirror.
2. This imaginary flat plane always stands completely normal or perpendicular to the horizontal principal axis.

(b) 1. The incident rays are identified as parallel rays that are completely inclined to the principal axis of the mirror.
2. The final image of the distant object is successfully formed at a single point strictly within the focal plane.

198. Tushar is playing with a thin beam laser pointer. He places a flat looking glass horizontally on the floor. He stands directly over it and shines the laser straight down so that the light hits the glass exactly perpendicularly. He observes that the light beam bounces right back up and hits the tip of the laser pointer itself. The diagram below illustrates the path of the light beam in his observation.



(a) State the angle of incidence for the light ray AO as shown in the diagram.
(b) Calculate the angle of reflection for this specific case.
(c) State what happens to the geometric path of a light ray when it is incident normally on a plane mirror.
(d) Identify the line that acts as both the incident ray and the normal in this specific diagram.

Ans :

(a) The angle of incidence for the light ray AO is exactly 0°, since the incident ray completely coincides with the normal.
(b) Formula: Angle of reflection (r) = Angle of incidence (i)
Substitution: $r = 0^{\circ}$
Result: $r = 0^{\circ}$.
(c) When a ray of light is incident normally on a plane mirror, it retraces its exact original path after undergoing reflection from the surface.
(d) The vertical straight line segment labelled AO effectively acts as both the incident ray and the normal to the reflecting surface in this diagram.

199. Kavita is solving a geometry problem related to optics in her assignment. She draws a ray diagram where a light beam strikes a horizontal mirror surface. However, instead of measuring the angle from the vertical reference line, she accidentally measures the angle between the incoming light ray and the mirror surface itself, noting it down as 30°. The diagram below shows her initial sketch before she completes the path of the bouncing ray.

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brother's throat, illuminating a very small area clearly. The doctor explains that this specific type of mirror is carefully chosen because of its unique ability to focus light rays effectively.

(a) Identify the type of spherical mirror used by the doctor and state the position where the light bulb must be placed to achieve the observed effect.

(b) Explain the physics principle behind this concentrated beam formation using rays.

Ans :

(a) 1. The doctor utilizes a specifically designed concave mirror to accurately concentrate the incoming light rays.
2. The small light bulb must be positioned precisely at the principal focus of this concave mirror.

(b) 1. The light rays originating from the bulb placed at the focus strike the concave reflecting surface.
2. After reflection, these diverging rays are converted into a strong parallel beam of light that intensely illuminates the target area.

184. Sanjay is conducting a physics activity in a dark room. He completely covers the front of a working flashlight with a thick black tape. He then carefully pierces a single small hole exactly in the centre of the tape. When he switches on the flashlight, a specific pattern of light rays emerges from the small hole and spreads out in all directions. He directs these light rays onto a wooden table, a book, and a glowing electric bulb in the room.

(a) Name the type of light beam produced by the flashlight with the small hole. Give one reason for your answer based on the direction of the light rays.

(b) Classify the wooden table and the glowing electric bulb into two different types of objects based on their ability to emit light. Define the type of object that the glowing electric bulb represents.

Ans :

(a) 1. The type of light beam produced by the flashlight through the small hole is known as a divergent beam of light.
2. This is because the light rays come out from a single point source and go out in all directions away from each other.

(b) 1. The wooden table is a non-luminous object, while the glowing electric bulb is classified as a luminous object in the surroundings.
2. Luminous objects are defined as those specific objects that have the ability to emit light by themselves, allowing them to be seen directly by us.

185. Rohan attends a science exhibition where various optical devices are displayed. In one section, he sees an image of a distant tree projected clearly onto a white paper screen. In another section, he looks into a standard plane looking glass and sees an image of his own face, but he notices that this image cannot be captured on a screen. He reads a placard explaining that different types of optical reflections produce different kinds of images with distinct orientations and characteristics.

(a) Name the specific kind of image that can be obtained on a screen.

(b) Name the specific kind of image formed by a plane mirror.

(c) State the vertical orientation of the image that is captured on the white paper screen.

(d) State the vertical orientation of the image formed by the plane looking glass.

Ans :

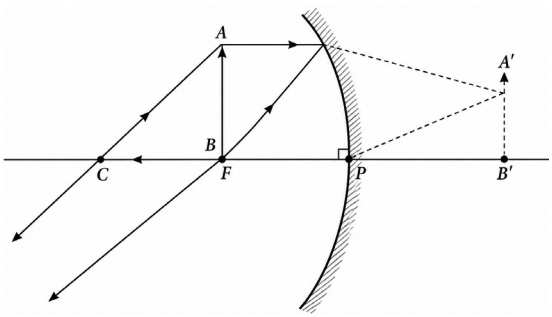
(a) A real image is the specific kind of image that can be successfully obtained and projected onto a screen after the reflection of light rays.

(b) A virtual image is the kind of image formed by a plane mirror, as the reflected light rays only appear to meet when produced backwards.

(c) A real image is always inverted in nature, meaning it appears upside down compared to the original physical orientation of the illuminated object.

(d) A virtual image is always erect or upright in nature, maintaining the exact same vertical orientation as the original physical object placed in front of it.

186. Kiran holds a small object very close to a curved mirror to observe its magnified reflection. He traces the paths of the light rays from the object to understand how the enlarged reflection is created behind the mirror surface.



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CHAPTER 8

Propagation of Sound Waves

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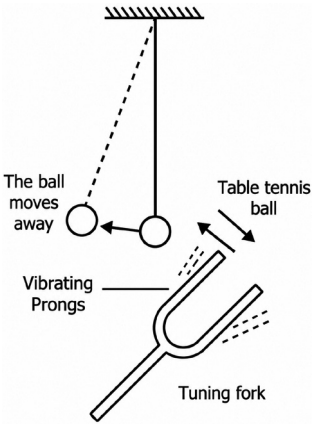
SUMMARY

1. PRODUCTION OF SOUND

When you strike a tuning fork, it starts vibrating. When this tuning fork is brought near the ear, we hear some sound. When this fork is brought near a hanging ball, the ball starts oscillating.

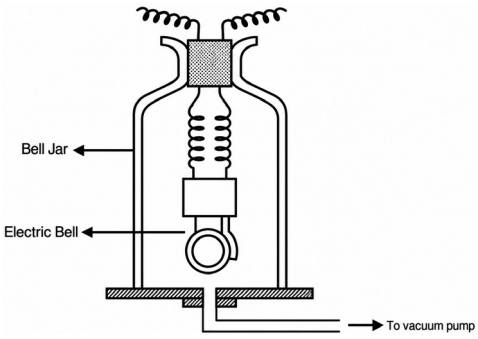


Thus, a vibrating source is necessary for the production of sound. Experiment to test the requirement of material medium

2. SOUND NEEDS A MATERIAL MEDIUM TO TRAVEL

1. Sound is a mechanical wave and needs a material medium to propagate. It cannot travel through vacuum.
2. The medium through which sound travels must have the following properties:
    1. It should be elastic so that its particles return to their initial positions after displacement.
    2. It should have inertia so that its particles have the capacity to store energy.
    3. It should be frictionless so that there is no loss of energy in propagation of sound through it.

2.1 Experiment to test the requirement of material medium



The hammer strikes the gong of the bell and sound is heard when the switch is pressed, that is, when the circuit is complete. If air is present inside the jar, then we are able to hear the sound. However, if air is removed, then the sound is not audible. The hammer is seen striking the gong, but the sound is not heard.

2.2 Propagation of Sound in a Medium

The matter or substance through which sound is transmitted is called a medium.

1. When an object vibrates, the particles in the surrounding medium vibrate. These particles send the vibrations to adjacent particles and energy continues to transmit until it reaches our ears.
2. The wave in which the particles of the medium vibrate about their mean position in the direction perpendicular to the direction of the propagation of waves is called a transverse wave.
3. A transverse wave is composed of alternate crests and troughs.

2.3 Characteristics of Wave Motion

The characteristics of wave motion are as follows:

1. A wave is produced by periodic disturbance at a point in the medium.
2. Due to the propagation of a wave in a medium, the particles of the medium vibrate

(a) Calculate the image distance using the mirror formula.
(b) State whether the image formed on the screen is real or virtual.
(c) State the orientation of this image relative to the object.

Ans :

(a) As we know that,

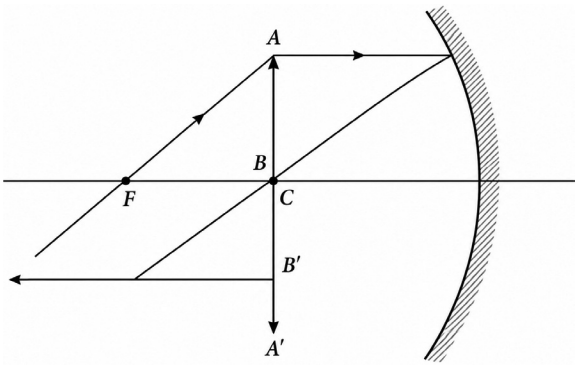
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{-15} - \frac{1}{-45}$$

$$v = -22.5 \text{ cm}$$

(b) The image formed on the screen is a real image because it can be successfully captured and observed on a physical cardboard screen.
(c) The orientation of the image relative to the object is inverted, as real images formed by concave mirrors are always upside down.

190. Varun sets up a spherical mirror on an optical bench. He places an upright object in front of the mirror and moves a screen until a sharp image forms exactly at the same location as the object. He draws the corresponding ray diagram in his journal.



(a) Identify the nature of the image formed in this setup.
(b) Compare the size of the image formed with the size of the object.
(c) If the object is placed at a distance of 40 cm from the pole to achieve this result, calculate the focal length of the mirror.

Ans :

(a) The nature of the image formed at the centre of curvature is strictly real and inverted, as it forms in front of the mirror.
(b) The size of the real image formed exactly at the centre of curvature is perfectly identical to the physical size of the original object.
(c) Formula: $f = \frac{R}{2}$

Substitution: $f = 4\frac{0}{2}$

Result: $f = 20$ cm

191. Tarun is practicing ray diagrams for spherical mirrors. He uses a ruler and pencil to draw specific incident rays striking a diverging mirror. He then determines the correct path of the reflected rays based on the laws of reflection.

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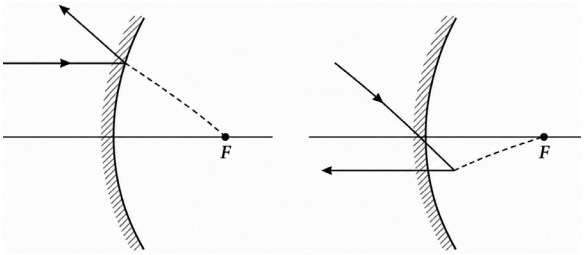
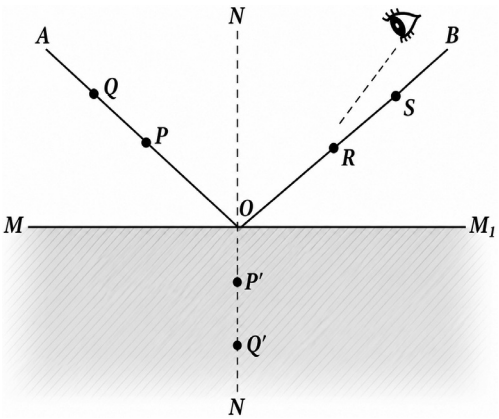


(a) Name the type of spherical mirror shown in these illustrations.
(b) State the rule of reflection demonstrated in the first illustration.
(c) State the rule of reflection demonstrated in the second illustration.
(d) State where the point marked F is located relative to the reflecting surface in this mirror.

Ans :

(a) The specific type of spherical mirror shown in these ray diagram illustrations is conclusively identified as a convex mirror.
(b) An incident light ray travelling parallel to the principal axis always appears to diverge exactly from the principal focus after reflection.
(c) An incident light ray aiming directly towards the principal focus consistently emerges parallel to the principal axis immediately after reflection.
(d) The principal focus of this diverging spherical mirror is securely located completely behind its outward bulging reflecting surface.

192. Kabir is performing an experiment on a flat wooden drawing board in his school laboratory. He fixes a sheet of white paper and places a glass strip with a silvered back surface vertically on it. He places two metal pins at specific positions and observes their images from the other side to place two more pins in a straight line. The diagram below shows his completed experimental layout.

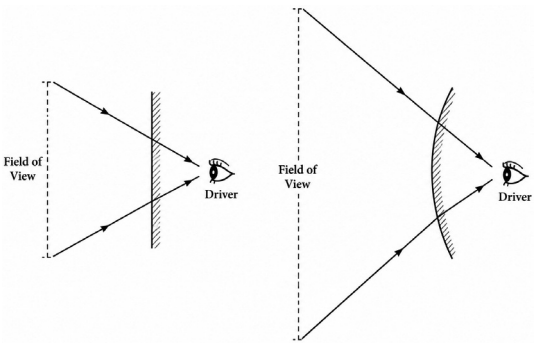


(a) Identify the line that represents the incident ray in the given diagram.
(b) Name the angle formed exactly between the line AO and the dashed line ON.
(c) State the two laws that Kabir will verify using this experimental setup.

Ans :

(a) The solid straight line labelled AO is the line that accurately represents the incident ray striking the reflecting surface in the given diagram.
(b) The angle formed exactly between the incident ray AO and the normal ON is termed as the angle of incidence.
(c) 1. The incident ray, the reflected ray, and the normal to the reflecting surface at the point of incidence all lie in the exact same plane.
2. The angle which the incident ray makes with the normal is always equal to the angle which the reflected ray makes with the same normal.

193. Anjali is studying the optical properties of different mirrors used in vehicles. She examines an illustration comparing the light gathering ability of two different reflecting surfaces placed at the same position. She notes the differences in the area covered by the reflected rays.

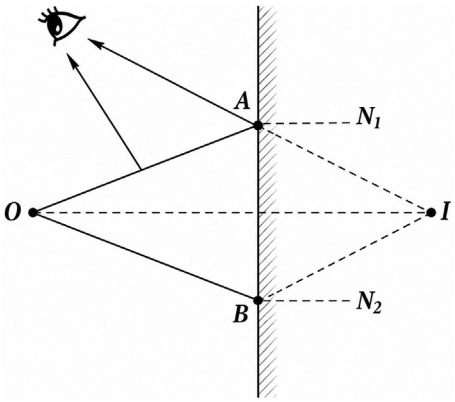


(a) Identify the type of mirror used in the second setup.
(b) State the specific use of this mirror in vehicles based on the property shown.
(c) Compare the nature and size of the image formed by the mirror in the second setup with that of the first setup.

Ans :

(a) The specific mirror used in the second setup demonstrating a much wider field of view is accurately identified as a convex spherical mirror.
(b) This specific type of mirror is extensively used as a rear-view mirror in vehicles to clearly monitor the wide traffic approaching from behind.
(c) 1. The first setup forms a virtual image identical in size to the object, whereas the second setup consistently forms a highly diminished image.
2. Both setups produce an erect and virtual image located completely behind the reflecting surface.

194. Vikram is learning how to locate the virtual image of a small glowing LED bulb placed in front of a flat mirror. He traces the path of two specific light rays originating from the bulb to see where they appear to come from after reflecting off the mirror surface. The diagram below shows the complete geometric construction of the light paths as observed by him.



(a) Identify the point that represents the virtual image in the given diagram.
(b) Name the dashed lines labelled N one and N two drawn perpendicular to the mirror surface.
(c) State the relationship between the perpendicular distance of O from the mirror and the perpendicular distance of I from the

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mirror. Explain why the image is considered virtual based on the rays in the diagram.

Ans :

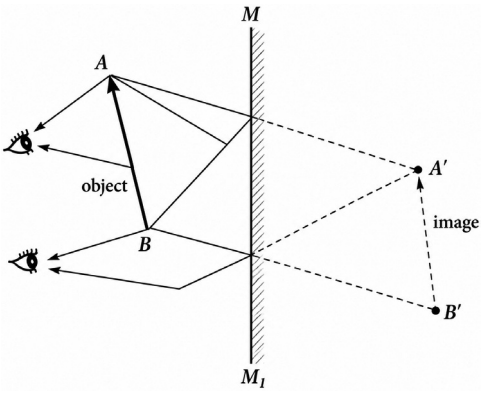
(a) The distinct point marked I behind the vertical mirror line represents the final virtual image formed in the given ray diagram.

(b) The dashed lines labelled N one and N two represent the normal drawn perpendicular to the reflecting surface at the respective points of incidence.

(c) 1. The perpendicular distance of the object O from the mirror is always exactly equal to the perpendicular distance of the image I from the mirror.

2. The image is virtual because the reflected light rays do not actually meet, but only appear to come from point I when produced backwards.

195. Deepa places a decorative sloping arrow piece in front of her dressing table mirror. She observes how the entire shape of the arrow is recreated behind the mirror. She draws a ray diagram in her notebook to understand how light from the top and bottom edges of the arrow reaches her eyes to form the complete reflection. The diagram below represents her drawing.



(a) State the geometric relationship between the perpendicular distance of point A from the mirror and the perpendicular distance of point A prime from the mirror. Name the nature of the image formed.

(b) Compare the size of the object AB with the size of the image A prime B prime. State whether this image is inverted or erect in nature.

Ans :

(a) 1. The perpendicular distance of point A in front of the mirror is exactly equal to the perpendicular distance of point A prime behind the mirror.

2. The nature of the complete image formed by the plane mirror is virtual, as the reflected light rays only appear to meet when produced backwards.

(b) 1. The size of the image A prime B prime is exactly equal to the original size of the extended object AB placed in front of it.

2. The extended image formed by the plane mirror is completely erect or upright in nature, retaining the identical vertical orientation as the original object.

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196. Neha is visiting an astronomical observatory and examines a dismantled telescope mirror. The mirror is a large portion of a hollow sphere of glass silvered on one side. She stretches a measuring tape straight across the circular boundary of the reflecting surface from one end to the other to find its width. She then marks the exact geometric centre of this reflecting curved surface with a tiny dot of ink. She imagines a straight line passing through this ink dot and the centre of the original glass sphere. Neha documents these precise geometric features in her notebook.

(a) Name the term used for the straight line distance across the boundary measured by Neha.

(b) Name the geometric centre of the reflecting surface marked by the ink dot.

(c) Name the point representing the centre of the imaginary sphere of which the mirror is a part.

(d) Name the imaginary straight line passing through the ink dot and the centre of the sphere.

Ans :

(a) The straight line distance measured across the circular boundary of the reflecting surface is officially termed as the linear aperture of the mirror.

(b) The exact geometric centre or the midpoint of the reflecting curved surface marked by the ink dot is known as the pole.

(c) The imaginary point representing the exact centre of the original hollow glass sphere is referred to as the centre of curvature.

(d) The imaginary straight line extending endlessly through both the pole and the centre of curvature is called the principal axis.

197. Divya projects a beam of sunlight onto a spherical mirror to study its focusing properties. She notices that the incoming rays are parallel to each other but hit the mirror at an angle. The diagram

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wooden cube in the space between the two mirrors. He then counts the number of virtual cubes he can see. Later, he reads a plaque explaining how the number of images changes if the mirrors are separated and placed completely parallel to each other.

(a) Calculate the number of images formed when the mirrors are inclined at 60°.

(b) State the rule used to find the final number of images when the calculated value of $360/\theta$ is an even number.

(c) State what happens to the number of images if the two mirrors are placed parallel to each other.

Ans :

(a) Number of images (n)

$$= (360^{\circ}/\theta) - 1$$

$$= (360^{\circ}/60^{\circ}) - 1$$

$$= 5 \text{ images.}$$

(b) If the calculated value of $360/\theta$ is an even number, the final number of images formed is always $(n-1)$ for all positions of the object between the mirrors.

(c) When two plane mirrors are placed strictly parallel to each other, an infinite number of images of an object placed between them are formed due to multiple reflections.

181. Karthik is drawing a coordinate system to map distances for a mirror experiment. He places the pole of the spherical mirror exactly at the origin of his graph paper. He aligns the principal axis of the mirror precisely along the horizontal X-axis of the coordinate system. He places a miniature toy car as the object on the left side of the mirror. He marks the direction of incident light travelling from the toy car towards the mirror surface. Karthik then measures the object distance, image distance, and object height according to the standard rules of measurement.

(a) State the sign of the object distance measured by Karthik.

(b) State the sign of the height of the toy car placed above the principal axis.

(c) State the rule for assigning a sign to a distance measured in the direction of incident light.

(d) State the rule for assigning a sign to distances measured below the principal axis.

Ans :

(a) According to the sign convention, the object distance measured by Karthik is always assigned a negative sign because it lies to the left.

(b) The height of the toy car placed upright above the principal axis is mathematically considered a positive value in the coordinate system.

(c) Any distance that is measured strictly along the principal axis in the same direction as the incident light is recorded as a positive value.

(d) Any vertical distance that is measured strictly below the horizontal principal axis of the mirror is always assigned a negative numerical value.

182. Meera is standing in a dance studio facing a vertical plane mirror fixed to a wall. Initially, she is standing at a distance of 4 m away from the mirror. She then steps backwards, moving an additional distance of 2 m away from the mirror. After pausing, she observes her reflection carefully. She raises her right hand and notices how the image responds. Finally, she imagines running directly towards the mirror to see how her image would appear to move.

(a) Calculate the total distance between Meera and her image after she steps backwards by 2 m.

(b) State the characteristic of the image formed by a plane mirror that relates to its vertical orientation.

(c) State what happens to the separation distance between Meera and her image if she shifts a distance d towards the mirror.

Ans :

(a) Total distance $= 2 \times$ (Initial distance + Distance moved away)

$$= 2 \times (4\text{m} + 2\text{m})$$

Total distance $= 12$ m

(b) The image formed by a plane mirror is always erect or upright in nature, which is a key characteristic of such virtual images.

(c) When Meera shifts a specific distance d towards the mirror, the total separation distance between her and her image will be reduced by $2d$.

183. Sunita accompanies her younger brother to an ear, nose, and throat specialist. She notices the doctor wearing a circular metallic mirror attached to a band around his forehead. The doctor positions a light bulb at a specific distance from this mirror. Sunita observes that the mirror reflects the light from the bulb into a highly concentrated beam. This bright beam is directed strictly inside her

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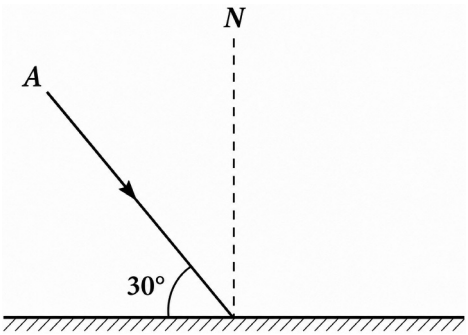


(a) Calculate the angle of incidence based on Kavita's diagram.
(b) Calculate the angle of reflection for this light ray.
(c) Name the dashed line marked N in the diagram.
(d) State the plane in which the incident ray, reflected ray, and the dashed line N will all lie.

Ans :

(a) Angle of incidence $= 90^{\circ}$ - Angle between incident ray and mirror surface

Angle of incidence $= 90^{\circ} - 30^{\circ}$

Angle of incidence $= 60^{\circ}$.

(b) Angle of reflection = Angle of incidence

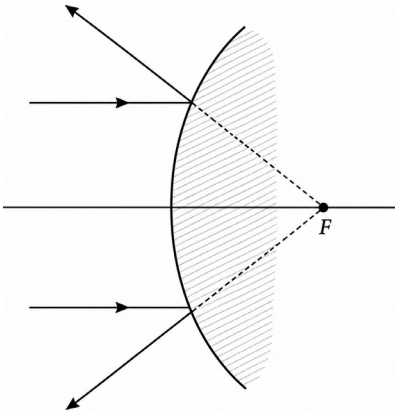
Angle of reflection $= 60^{\circ}$

Angle of reflection $= 60^{\circ}$.

(c) The dashed vertical line marked N drawn strictly perpendicular to the horizontal reflecting surface at the point of incidence is called the normal.

(d) The incident ray, the reflected ray, and the normal will all essentially lie in the exact same plane, which is termed the plane of incidence.

200. Rohit observes the design of a street lamp assembly during his evening walk. He notices a curved metallic surface placed behind the light bulb. He finds a technical drawing of this exact reflector design in his physics textbook showing how light rays spread over a large area.



(a) Identify the property of the mirror demonstrated by the spreading out of the reflected rays.
(b) State the exact purpose of using this specific curved surface in street lamps.
(c) Name the point where the dashed lines meet behind the curved surface.
(d) State whether the focus of this mirror is real or virtual based on the rays.

Ans :

(a) The optical property demonstrated by the continuous spreading out of the reflected light rays is known as the diverging action of the mirror.

(b) This specific curved surface is heavily utilized as a street lamp reflector to successfully diverge light rays over a significantly larger geographical area.

(c) The specific marking where the dashed lines appear to meet behind the curved reflecting surface is called the principal focus.

(d) The principal focus of this particular mirror is strictly virtual because the reflected light rays only appear to meet at that specific location.

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(a) State the physical nature of the image formed in this specific arrangement and give one common practical use for it.
(b) Describe the position of the object relative to the mirror's defining points and state what happens to the size of the image as the object moves closer to point P.

Ans :

(a) 1. The image formed in this specific arrangement is strictly virtual, upright, and significantly magnified in size.
2. This exact optical setup is practically applied when utilizing a concave mirror as a shaving or makeup mirror.
(b) 1. The physical object is explicitly placed between the principal focus and the pole of the concave mirror.
2. As the object gradually moves closer to the pole, the size of the virtual image decreases accordingly.

187. Rahul visits a science museum where three unmarked spherical mirrors are mounted on a wall. The mirrors are identical in external shape and size. A museum guide challenges Rahul to identify each mirror without touching their surfaces. Rahul stands close to the first mirror and observes an erect image of his face that is the exact same size. He moves to the second mirror, stands very close, and sees a highly magnified, erect image of his face. He then stands in front of the third mirror and observes an erect but much smaller image of his face. He steps back from all three mirrors and notes how the images change.
(a) Identify the second and third mirrors based on Rahul's observations.
(b) Describe what will happen to the size of the image in the third mirror if Rahul moves further away from it.

Ans :

(a) 1. The second mirror forms a highly magnified and erect image when held close, which strictly identifies it as a concave mirror.
2. The third mirror forms a diminished and erect image regardless of position, which clearly identifies it as a convex mirror.
(b) 1. As Rahul physically moves further away from the third convex mirror, the size of the virtual image will continue to decrease gradually.
2. The diminished virtual image will progressively shift closer towards the principal focus but will never travel beyond it.

188. Neha is sitting in her father's car, looking at the flat rear-view mirror. She notices a large white emergency vehicle driving closely behind them. The front of the vehicle has the word AMBULANCE painted on it, but the letters appear strangely written when she turns around to look at it directly. However, when she looks at the vehicle through the rear-view mirror again, the word is perfectly readable. She later writes the letters 'A', 'M', 'P', and 'B' on a paper to study this effect in her dressing mirror.
(a) Name the phenomenon that causes the word on the vehicle to appear correctly readable in the rear-view mirror.
(b) State why the word is painted in that specific strange manner on the front of the vehicle.
(c) From the letters Neha wrote, identify one letter whose image will not show any noticeable change in the mirror.
(d) Give one reason why the image of the letter identified in (c) remains unchanged upon reflection.

Ans :

(a) The phenomenon that causes the word to appear properly readable in the rear-view mirror is termed as lateral inversion of the image.
(b) The text is written laterally inverted so that drivers ahead can read the word perfectly upright in their rear-view mirrors and give side to pass.
(c) The letter 'A' is one specific letter from the group whose image will completely remain unchanged and not show noticeable lateral inversion.
(d) The image remains unchanged because the letter has a perfect geometric symmetry about a vertical line passing exactly through the mid-point of the letter.

189. Arjun is conducting an optical bench experiment in his school laboratory. He places a brightly lit candle in front of a concave mirror to study image formation. The mirror provided to him has a focal length of 15 cm. He precisely positions the candle at a distance of 45 cm from the pole of the mirror. He uses a white cardboard screen to capture the reflection formed by the mirror. He moves the screen back and forth along the bench until a sharp, clear image of the candle flame appears. He carefully records the object and image distances in his observation table for his final practical report.

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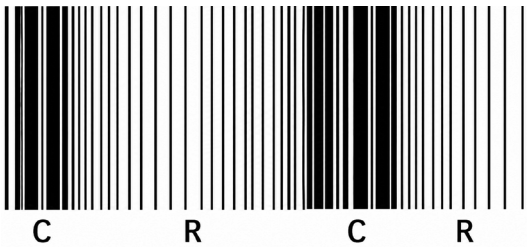
about their mean positions, and energy is transferred from one place to another in the medium with a constant speed.

2.4 Sound Waves are Longitudinal Waves

1. Sound propagates in a medium as a series of compressions and rarefactions.
2. A longitudinal wave is a wave where the individual particles vibrate parallel to the direction of the propagation of the wave.
3. Sound waves also propagate in the same manner, and hence, they are longitudinal waves.
4. A longitudinal wave is composed of alternate compressions and rarefactions.



Terms Related to Wave Motion

5. Amplitude: The maximum displacement of a particle of a medium on either side of the mean position is called the amplitude of a wave. It is denoted by 'a' or 'A'. Its SI unit is metre (m).
6. Time period: The time taken by the particle of a medium to complete one vibration is called the time period of the wave. It is denoted by 'T'. Its SI unit is second (s).
7. Frequency: The number of oscillations made by the particle of the medium per unit time is called the frequency of the wave. It is denoted by 'n', 'f or v.
   It is also given as the number of compressions or rarefactions which cross a point per unit time. Its SI unit is second -1 or hertz (Hz).
   Wavelength: The distance travelled by a wave in one time period of a vibration of a particle of a medium is called the wavelength of the wave. It is denoted by 'λ'. Its SI unit is metre (m).
   In a longitudinal wave, the distance between two consecutive compressions or two consecutive rarefactions is equal to the wavelength of the wave. Similarly, in a transverse wave, the distance between two consecutive crests or two consecutive troughs is equal to the wavelength of the wave.
8. Wave velocity: The distance travelled by a wave in one second is called wave velocity. It is denoted as 'V'. Its SI unit is metre per second (m s^{-1}).

2.5 Relation between wavelength, wave velocity and frequency

The relation between wavelength ,wave velocity and frequency is as follows :

$$V = v\lambda$$

Thus, wave velocity is the product of wavelength and frequency.

3. SPEED OF SOUND IN DIFFERENT MEDIA

The speed of sound in a medium depends on the following two factors:

1. Elasticity E of the medium
2. Density ρ of the medium

The speed of sound in a medium is given as

$$V = \sqrt{\frac{E}{\rho}}$$

Newton derived the above formula assuming that the temperature of a gas in which sound travels does not change. Hence, the above equation should contain isothermal elasticity which is equal to pressure.

$$V = \sqrt{\frac{P}{\rho}}$$

Laplace corrected this formula considering an adiabatic change. For an adiabatic change, the modulus of elasticity is E = γ P, where y is the ratio of specific heat at constant pressure to the specific heat at constant volume

$$V = \sqrt{\frac{\gamma P}{\rho}}$$

3.1 Factors Affecting the Speed of Sound in a Gas Effect of density

The speed of sound is given as $V = \sqrt{\frac{\gamma P}{\rho}}$.Thus, we can say that speed is inversely proportional to the square root of density of the gas $V \propto \sqrt{\frac{1}{\rho}}$
square root of density of the gas V .

Effect of temperature

1. The speed of sound in a gas increases with increase in temperature. This is because with increase in temperature, the density of gas decreases and hence speed increases.
2. Speed is directly proportional to the square root of temperature $V \propto \sqrt{T}$. Here, T is measured in Kelvin.
3. The speed of sound increases by 0.61 m s^{-1} for every degree rise in temperature.

$$V = V_0 + 0.61t$$

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Ans : (C)

Sound strictly requires a material medium to propagate. As air is continuously pumped out of the bell jar, fewer particles remain available to transmit the mechanical vibrations from the gong to the jar walls, which steadily decreases the sound loudness.

8. The hearing frequency ranges of different organisms are documented.

Organism	**Lower Frequency Limit**	**Upper Frequency Limit**
Human	20 Hz	20 kHz
Elephant	16 Hz	12 kHz
X	10 kHz	100 kHz
Dog	67 Hz	45 kHz

Given that organism X uses high-frequency sound for echolocation, which animal is most likely represented by X?
(A) Whale
(B) Grasshopper
(C) Bat
(D) Cat

Ans : (C)

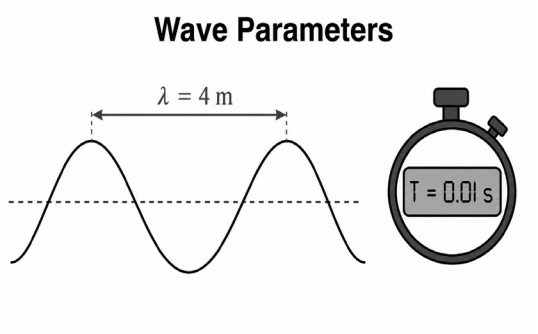
The hearing range for organism X extends up to 100 kHz, which is well into the ultrasonic range (frequencies above 20 kHz). Bats are well-known for using high-frequency ultrasonic sounds for echolocation to navigate and find prey. The range given in the table is characteristic of a bat's hearing capability.

9. Which of the following best defines a longitudinal wave?
(A) A wave in which particles vibrate perpendicular to the direction of wave propagation
(B) A wave in which particles vibrate along the line of direction of the propagation of the wave
(C) A wave that propagates only through the surface of liquids
(D) A wave that consists entirely of crests and troughs

Ans : (B)

A longitudinal wave is defined as a wave where the particles of the medium vibrate directly along the line of propagation of the wave. These waves are effectively transmitted in the distinct form of alternating compressions and rarefactions through matter.

10. A sound wave is measured to have a wavelength (λ) of 4 m and a time period (T) of 0.01 s. Based on the information in the diagram, what is the speed of this wave?



(A) 0.04 m/s
(B) 25 m/s
(C) 400 m/s
(D) 4.01 m/s

Ans : (C)

Explanation: The speed of a wave (v) is related to its frequency (f) and wavelength (λ) by the formula $v = f\lambda$. The frequency is the reciprocal of the time period ($f = 1/T$). Here, $f = 1 / 0.01$ s = 100 Hz. Therefore, the speed $v = 100$ Hz $\times$ 4 m = 400 m/s.

11. In a displacement-time graph of a wave, what does the horizontal axis represent?
(A) The distance travelled by the wave
(B) The time elapsed
(C) The maximum amplitude of the wave
(D) The velocity of the individual vibrating particles

Ans : (B)

A displacement-time graph clearly represents the continuous variation of displacement with respect to time for a specific particle of the medium. Therefore, the horizontal axis correctly denotes the time elapsed as the wave continuously propagates through the given medium.

12. Identify the correct statements regarding non-mechanical waves.
I. They require a material medium for propagation.
II. Light waves are examples of non-mechanical waves.
III. They cannot travel through a vacuum.
IV. X-rays and gamma rays are classified under this category.
(A) I and II (B) II and IV
(C) I, II and III (D) II, III and IV

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2. When a spring is attached to one prong of a vibrating tuning fork, certain regions show coils coming closer together. What happens to the density of the air particles in these specific regions?
(A) The density decreases significantly
(B) The density becomes zero
(C) The density remains completely unchanged
(D) The density increases

Ans : (D)

In the region of compression formed by the vibrating tuning fork, the coils of the spring come much closer together. Consequently, the particles of the surrounding air also move closer, which directly increases the overall air density in that region.

3. In an experiment, a vibrating tuning fork is brought near a suspended table tennis ball. The ball starts jumping to and fro. What does this specific observation directly prove?
(A) Sound requires a medium to travel
(B) Sound travels faster in solids
(C) A vibrating body is a source of sound
(D) Sound waves are non-mechanical in nature

Ans : (C)

When the vibrating tuning fork is brought close to the suspended table tennis ball, the ball immediately begins jumping to and fro. This specific physical interaction clearly demonstrates that a vibrating body acts as the primary source for producing sound.

4. Read the assertion and reason carefully, then choose the correct option.
Assertion (A) : A material medium required for the propagation of sound must possess elasticity.
Reason (R) : Elasticity allows the particles of the medium to return to their initial positions after displacement.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

For sound to propagate, the medium must be highly elastic. This essential property ensures that after the particles are displaced on either side during wave motion, they are completely capable of returning to their original mean positions to continue vibrations.

5. What actually transfers from one medium point to another due to the propagation of a wave, without the actual movement of matter?
(A) Force and velocity
(B) Energy and momentum
(C) Mass and acceleration
(D) Inertia and elasticity

Ans : (B)

Due to the continuous propagation of a wave within a medium, only the transfer of energy and momentum occurs from one point to another. This entire transfer efficiently happens without the actual physical movement of matter between the two sites.

6. A sound wave propagates through air, creating regions of varying pressure and density. The properties of two such distinct regions, X and Y, are tabulated.

Region	Particle Spacing	Local Pressure
X	Closer than normal	Higher than normal
Y	Farther apart than normal	Lower than normal

Based on the table, what do regions X and Y represent in the longitudinal wave?
(A) X is a rarefaction, Y is a compression.
(B) X is a crest, Y is a trough.
(C) X is a compression, Y is a rarefaction.
(D) X is a trough, Y is a crest.

Ans : (C)

A compression is a region in a longitudinal wave where particles are crowded together, resulting in higher-than-normal density and pressure. A rarefaction is a region where particles are spread apart, causing lower-than-normal density and pressure. The table's data for X matches a compression, and the data for Y matches a rarefaction.

7. During the bell jar experiment, as air is gradually withdrawn using a vacuum pump, the hammer is still seen striking the gong repeatedly, but the loudness of sound decreases. Why does this happen?
(A) The gong stops vibrating without air
(B) The mechanical energy of the hammer decreases
(C) The number of particles available to transmit vibrations reduces
(D) The frequency of the gong's vibrations drastically decreases

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Property	Light Wave	Sound Wave
A	Can travel in vacuum	Cannot travel in vacuum
B	Longitudinal wave	Transverse wave
C	Speed is greater in glass than in air	Speed is greater in air than in steel
D	Requires a medium	Does not require a medium

Which row presents a correct comparison between light and sound waves?

(A) A (B) B
(C) C (D) D

Ans : (A)

Light is an electromagnetic wave and can propagate through a vacuum, whereas sound is a mechanical wave and requires a material medium. Row A correctly states this difference. Row B is incorrect; light is transverse and sound is longitudinal. Row C is incorrect as light slows down in glass and sound speeds up in steel.

29. Read the assertion and reason carefully, then choose the correct option.

Assertion (A) : The speed of sound calculated using Newton's formula was found to be significantly lower than the experimental value.

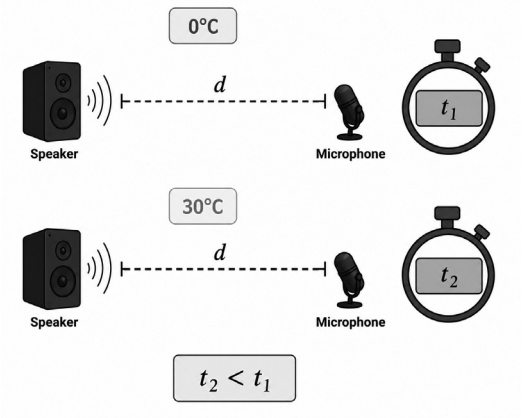
Reason (R) : Newton incorrectly assumed that the propagation of sound in a gas is an adiabatic change where temperature varies.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The assertion is true because Newton's calculated speed was indeed lower. However, the reason is false because Newton initially assumed the propagation was an isothermal change. It was actually the scientist Laplace who later correctly identified it as an adiabatic process.

30. The experiment shown measures the time for a sound to travel a fixed distance 'd' at two different temperatures. The time taken is shorter at the higher temperature. What does this observation imply?



(A) The speed of sound is inversely proportional to temperature.
(B) The speed of sound is directly proportional to the square root of its absolute temperature.
(C) The frequency of sound increases with temperature.
(D) The wavelength of sound decreases with temperature.

Ans : (B)

Explanation: Since the distance 'd' is constant, a shorter time 't_2' at a higher temperature implies a higher speed. The speed of sound in a gas is directly proportional to the square root of its absolute temperature ($v \propto \sqrt{T}$). This is because an increase in temperature increases molecular motion, causing the disturbance to propagate faster.

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31. Which of the statements correctly describe wavelength?

I. It is the linear distance between two consecutive compressions.
II. It is the linear distance between a crest and an adjacent trough.
III. It depends on the medium in which the wave travels.
IV. At a lower frequency, wavelength becomes higher.

(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

Ans : (B)

Wavelength is the distance between two consecutive compressions or two consecutive crests, not between a crest and a trough. It strictly depends on the medium. Additionally, at a uniformly lower frequency, the corresponding wavelength becomes significantly higher and vice-versa.

Ans : (B)

Non-mechanical waves do not require any material medium for propagation and can easily travel through a vacuum. Common examples include electromagnetic waves like light waves, X-rays, and gamma rays. Thus, statements involving the requirement of a material medium are entirely incorrect.

13. An experiment investigates how different physical parameters affect the speed of a sound wave in a gas. The initial speed of sound is 340 m/s.

Trial	Parameter Changed	Consequence of Change	Expected Final Speed
1	Temperature	Increased	Greater than 340 m/s
2	Humidity	Increased	Greater than 340 m/s
3	Pressure	Doubled (at constant T)	Z
4	Wind	Blowing against sound	Less than 340 m/s

What is the expected value of the final speed Z in Trial 3?
(A) 680 m/s (B) 170 m/s
(C) 340 m/s (D) 480 m/s

Ans : (C)

The speed of sound in a gas is independent of changes in pressure, provided the temperature remains constant. When pressure is doubled, the density of the gas also doubles, keeping the ratio P/ρ constant. Since the speed of sound depends on this ratio, it does not change. Therefore, the final speed remains 340 m/s.

14. Which of the following correctly represents the mathematical relationship between wave velocity (v), frequency (f), and wavelength (lambda)?
(A) v = f / lambda
(B) v = lambda / f
(C) v = f lambda
(D) f = v lambda

Ans : (C)

By standard definition, the wave velocity represents the total distance travelled by the wave in one second. Since the distance travelled in one time period is the wavelength, the correct mathematical relationship is formulated precisely as v = f lambda.

15. A person stands at a known distance (d) from a high cliff and fires a pistol. If the time interval noted for the echo is (t), what is the correct formula to calculate the speed of sound (v)?
(A) v = d / t (B) v = 2d / t
(C) v = d / 2t (D) v = (2d) t

Ans : (B)

When measuring using the echo method, the generated sound first travels a distance exactly equal to d to reach the cliff, and then perfectly reflects back the exact same distance. Thus, the total distance is 2d, making the formula v = 2d/t.

16. If the speed of sound in dry air at 0 degrees Celsius is exactly 330 m/s, what will be the approximate speed of sound in air at 10 degrees Celsius?
(A) 336.1 m/s
(B) 345.2 m/s
(C) 323.9 m/s
(D) 330.6 m/s

Ans : (A)

The speed of sound in air uniformly increases by exactly 0.61 m/s for every single degree Celsius rise in temperature. Thus, for a ten-degree rise, the total increase is 6.1 m/s, yielding a final calculated speed of precisely 336.1 m/s.

17. Which of the following statements about transverse waves is strictly incorrect?
(A) They are composed of alternating crests and troughs
(B) The particles of the medium vibrate perpendicular to the wave propagation direction
(C) Gases can easily transmit transverse waves because they lack rigidity
(D) Solids can transmit both transverse and longitudinal waves

Ans : (C)

Gases are entirely unable to transmit transverse waves because they lack the necessary rigidity to restore forces in all directions. Consequently, gases can only transmit longitudinal waves, whereas solids can successfully transmit both transverse and longitudinal types of waves.

18. The speed of sound in oxygen is approximately one-fourth the speed of sound in hydrogen. What correctly explains this observation according to the density relation?
(A) Oxygen is 4 times denser than hydrogen
(B) Oxygen is 16 times denser than hydrogen
(C) Oxygen is 8 times denser than hydrogen

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Effect of humidity

4. The speed of sound in air increases with increase in humidity.
5. The density of water vapour is (5/8)th times the density of dry air. Thus, with increase in moisture, density decreases, and hence, the speed of sound increases.
6. Thus, sound travels faster in moist air than in dry air.

Effect of direction of wind

If wind is blowing in the direction of propagation of sound, then the speed of sound increases.
However, if wind direction is opposite to the direction of propagation of sound, then the speed of sound decreases.

The Speed of Sound is Independent of the Following Factors

7. Wavelength (or frequency) of wave
8. Amplitude of wave
9. Pressure The speed of sound is given as $V = \sqrt{\frac{\gamma P}{\rho}}$. From this equation, one would feel that depends on pressure P, but it is independent of P.
   When pressure increases, volume decreases but the mass remains the same; thus, density increases such that P/ρ remains the same. Hence, V is independent of P.

Infrasonic, Sonic and Ultrasonic Frequencies Range of Hearing

10. The audible range of sound for human beings extends from 20 Hz to 20000 Hz.
11. This audible range varies from person to person and also with age.
12. The hearing sensitivity to higher frequencies is reduced as one grows older.
13. Children under the age of 5 years and some animals can hear up to 25 kHz.
14. The human ear is most sensitive to sound in the range from 2000 Hz to 3000 Hz.
15. Sound of frequency less than 20 Hz is called infrasonic sound, whereas sound of frequency higher than 20 kHz is called ultrasonic sound

Frequency ranges for hearing and speaking

Living creature	Frequency range
Human	Hz - 20 kHz
Dog	Hz - 50 kHz
Grasshopper	Hz - 1 kHz
Cat	Hz - 60 kHz
Bat	Hz - 100 kHz
Dolphins	Hz - 150 kHz

Applications of Ultrasound

16. Ultrasounds are high-frequency waves. These waves are able to travel along well-defined paths even in the presence of obstacles.
17. Ultrasounds are able to travel freely in solids and liquids, but in gases, their intensity reduces considerably.
18. Ultrasounds are used extensively in industries and for medical purposes.

Properties of Ultrasound

Properties of ultrasound are similar to ordinary sound, but due to high frequencies, they also have the following properties:

19. The energy carried by ultrasound is very high.
20. It can travel along a well-defined straight path. It does not bend much along the edges of an obstacle as it has very small wavelength.

Applications of Ultrasound

21. Ultrasound is generally used to clean parts located in hard - to - reach places.
22. Ultrasounds can be used to detect cracks and flaws in metal blocks.
23. Ultrasonic waves are made to reflect from various parts of the heart and form the image of the heart. This technique is called Echocardiography.
24. Ultrasonography is used to obtain images of patient's organs such as the liver and kidneys. It helps to detect stones in the kidneys.
25. Ultrasound can be used to remove cataract and to break stones in the kidneys into fine grains.
26. SONAR (Sound Navigation and Ranging) uses ultrasound to detect and find the distance of objects under water.

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OBJECTIVE QUESTIONS

1. What primary form of energy is responsible for creating vibrations in a body that subsequently produce sound?
(A) Mechanical energy
(B) Heat energy
(C) Electrical energy
(D) Light energy

Ans : (A)

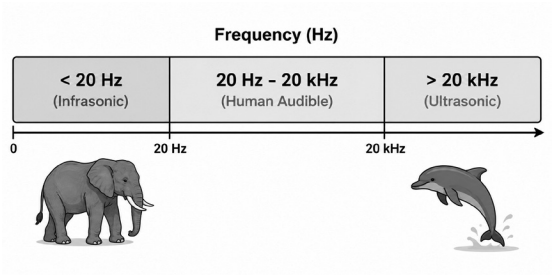
Sound waves are fundamentally characterised by the motion of particles within a medium. It is the mechanical energy that successfully creates vibrations in a body. These resulting vibrations are then transmitted to the molecules of the surrounding medium to produce sound.

(B) Amplitude: Maximum displacement of medium particles, Metre
(C) Wavelength: Total number of vibrations in one second, Metre
(D) Wave velocity: Distance travelled by wave in one time period, Metre per second

Ans : (B)

Amplitude is accurately defined as the maximum displacement of the particles of a medium on either side of their mean position. Since it strictly measures a physical distance, its accepted standard SI unit is correctly identified as the metre.

24. The diagram shows a spectrum of sound frequencies. Based on their known communication methods, where would the sounds produced by an elephant and a dolphin typically fall on this spectrum?



(A) Elephant: Human Audible; Dolphin: Ultrasonic.
(B) Elephant: Infrasonic; Dolphin: Ultrasonic.
(C) Elephant: Ultrasonic; Dolphin: Infrasonic.
(D) Elephant: Infrasonic; Dolphin: Human Audible.

Ans : (B)

Explanation: Elephants communicate over long distances using low-frequency sounds below the range of human hearing (< 20 Hz), which is known as infra-sound. Dolphins use high-frequency clicks and whistles for echolocation and communication, with frequencies extending well above human hearing (> 20 kHz), which is known as ultrasound.

25. Arrange the following media in the strictly increasing order of the speed of sound propagating through them: Water, Air, Steel.
(A) Air, Water, Steel
(B) Water, Air, Steel
(C) Steel, Water, Air
(D) Air, Steel, Water

Ans : (A)

The speed of sound is distinctly maximum in solid materials, comparatively less in liquids, and least in gases. Therefore, sound predictably travels slowest in gaseous air, significantly faster in liquid water, and reaches its absolute maximum speed in solid steel.

26. Which of the following properties are essential for a medium to propagate sound?
I. The medium must be highly compressible and dense.
II. The medium must possess inertia to store mechanical energy.
III. The medium must be completely frictionless to prevent energy loss.
IV. The medium must be inelastic to sustain continuous wave propagation.
(A) I and II
(B) II and III
(C) III and IV
(D) I and IV

Ans : (B)

A medium needed for sound propagation must exhibit specific properties. It must have inertia to successfully store mechanical energy. Additionally, the medium must be frictionless so that there is absolutely no energy loss during the continuous propagation of sound waves.

27. Read the assertion and reason carefully, then choose the correct option.
Assertion (A) : When a stone is dropped in a quiet pond, a cork on the water surface simply tosses up and down without any forward displacement.
Reason (R) : The water particles travel progressively outward from the point of disturbance to carry the wave forward.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The assertion is entirely true, as the cork merely tosses up and down. However, the reason is false because water particles themselves do not travel outward; they simply vibrate about their mean positions while only the disturbance travels progressively forward.

28. The fundamental properties of light waves and sound waves are compared.

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This common visual and auditory delay occurs exclusively because the speed of light is exceptionally much faster than the speed of sound. Thus, the visual image of the strike reaches the spectator's eyes almost instantly compared to the slower sound.

37. In the direct method for determining the speed of sound using a pistol and a stopwatch, why is it highly recommended to take readings by firing from both locations (A and B)?
(A) To perfectly eliminate the inherent delay of the observer's reaction time
(B) To completely minimise the error introduced by the prevailing wind direction
(C) To effectively double the total distance travelled by the sound wave
(D) To strictly prevent the pistol's loud flash from fading too quickly

Ans : (B)

During this specific outdoor experiment, firing sequentially from both selected locations and then meticulously averaging the recorded times is crucial. This procedural step is specifically designed to effectively minimise any timing error directly caused by the prevailing environmental wind conditions.

38. Which of the following statements concerning the audible range of human hearing is entirely incorrect?
(A) The normal audible range for a human ear spans from roughly 20 Hz to 20,000 Hz
(B) The exact audible range greatly depends on various environmental factors and individual age
(C) Older people can routinely hear extremely high frequencies effortlessly up to 30 kHz
(D) Prolonged daily exposure to very loud sounds distinctly decreases the audible range in humans

Ans : (C)

Generally, young children can clearly hear sounds having frequencies up to 30 kHz. However, significantly older people often suffer an unfortunate reduction in their hearing capabilities and typically may only manage to hear sound frequencies strictly up to 12 kHz.

39. What specific biological organ's mechanical workings are primarily studied using the advanced technique known as seismocardiography?
(A) The liver (B) The heart
(C) The human brain (D) The skeletal lungs

Ans : (B)

Seismocardiography is a highly specialised medical technique explicitly utilised to thoroughly study and monitor the complex mechanics of the beating human heart. It directly relies on the precise detection of characteristic infrasonic waves naturally emitted during the organ's continuous pumping.

40. The speed of sound was measured in three different substances at the same temperature. The results are shown below.

Substance	State of Matter	Speed of Sound (m/s)
P	Gas (Air)	343
Q	Liquid (Water)	1480
R	Solid (Steel)	5100

What general conclusion can be drawn from this data?
(A) The speed of sound is constant in all media.
(B) The speed of sound is greatest in gases and least in solids.
(C) The speed of sound depends on the state of the medium.
(D) The speed of sound is independent of the medium's density.

Ans : (C)

The table clearly shows that the speed of sound varies significantly with the state of matter: 343 m/s in gas, 1480 m/s in liquid, and 5100 m/s in solid. This demonstrates that the speed of sound is not constant but depends directly on the properties of the medium through which it propagates.

41. The sound of frequencies perfectly below 20 Hz is formally known as:
(A) Supersonic sound
(B) Ultrasonic sound
(C) Mega-sonic sound
(D) Infrasonic sound

Ans : (D)

Any sound possessing a frequency strictly below the standard 20 Hz threshold is formally classified as infrasonic sound or infra-sound. This specific type of low-frequency acoustic energy is notably produced by massive natural disasters like violent earthquakes and ocean waves.

42. The diagram shows two scenarios where a person is listening to a sound source. The wind is blowing with a speed 'W' and the speed of sound in still

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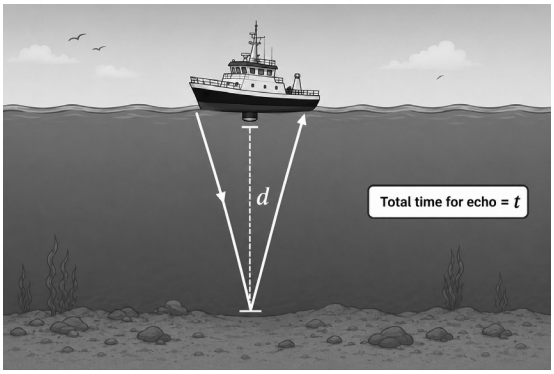
32. The principle of SONAR is illustrated in the diagram, where a ship detects the seabed. If the speed of ultrasound in water is 'v' and the time for the echo to return is 't', which formula correctly gives the depth 'd'?



(A) $d = v \times t$ (B) $d = v / t$
(C) $d = (v \times t) / 2$ (D) $d = 2 \times v \times t$

Ans : (C)

Explanation: The time 't' measured by SONAR is the total time for the sound pulse to travel down to the seabed and back up to the ship's detector. This means the sound travels a total distance of 2d. Using the formula distance = speed × time, we get $2d = v \times t$. Therefore, the depth 'd' is $(v \times t) / 2$.

33. Read the assertion and reason carefully, then choose the correct option.
Assertion (A) : During a thunderstorm, the flash of lightning is seen much earlier than the sound of thunder is heard.
Reason (R) : Light waves are transverse electromagnetic waves whereas sound waves in air are longitudinal mechanical waves.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (B)

Both the assertion and the reason are fundamentally true statements. However, the exact reason we observe lightning earlier is strictly due to the massive difference in their respective travelling speeds, not because of their distinctly different structural wave classifications.

34. A sound signal is sent over a distance of 3.3 km through three different media. The time taken for the signal to travel this distance in each medium is recorded.

Medium	Distance	Time Taken
P	3.3 km	10 s
Q	3.3 km	2.23 s
R	3.3 km	0.625 s

Based on the known relative speeds of sound, identify the media P, Q, and R.
(A) P: Water, Q: Air, R: Steel
(B) P: Air, Q: Water, R: Steel
(C) P: Steel, Q: Water, R: Air
(D) P: Air, Q: Steel, R: Water

Ans : (B)

Sound travels fastest in solids, then liquids, and slowest in gases. A shorter travel time over the same distance implies a higher speed. Medium R has the shortest time (0.625 s), so it is the fastest (Steel). Medium P has the longest time (10 s), so it is the slowest (Air). Medium Q is intermediate (Water).

35. Which combination of factors does NOT affect the speed of sound in a gas?
I. Amplitude of the sound wave.
II. Direction of the prevailing wind.
III. Wavelength of the sound wave.
IV. Atmospheric pressure of the gas.
(A) I, II and IV
(B) II, III and IV
(C) I, III and IV
(D) I, II and III

Ans : (C)

The speed of sound in a continuous gaseous medium is completely independent of the wave's amplitude, its wavelength, and the surrounding atmospheric pressure. Conversely, the direction of the wind measurably alters the effective speed of sound travelling through the air.

36. Spectators watching a cricket match often hear the sound of the bat striking the ball a little later than they actually see the batsman making the strike. What is the fundamental cause?
(A) The speed of sound is vastly greater than the speed of light
(B) The speed of light is roughly equal to the speed of sound in air
(C) Sound requires a medium while light effectively travels instantaneously across short distances
(D) The speed of light is significantly faster than the speed of sound

Ans : (D)

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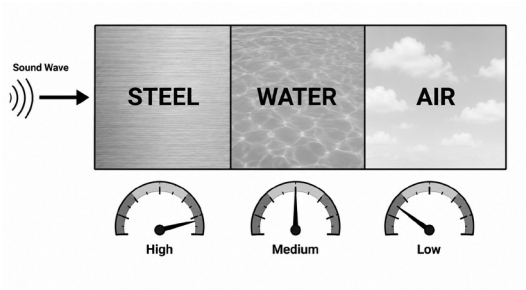
(D) Hydrogen is 16 times denser than oxygen

Ans : (B)

The speed of sound in any given gas is strictly inversely proportional to the square root of its density. Since oxygen is sixteen times denser than hydrogen, the square root relationship accurately makes the sound speed one-fourth that in hydrogen.

19. The diagram shows that sound travels at different speeds in steel, water, and air. Which statement correctly explains why the speed of sound is greatest in steel?



(A) Steel has the lowest density of the three media.
(B) Steel is highly elastic and its particles are closely packed.
(C) Sound waves become transverse in solids, which are faster.
(D) The temperature of steel is always higher than that of water or air.

Ans : (B)

Explanation: The speed of sound depends on both the elasticity and density of the medium ($v = \sqrt{(E/\rho)}$). Although solids are denser than liquids or gases, their modulus of elasticity is significantly higher. This high elasticity, combined with the close packing of particles, allows vibrations to be transmitted much more rapidly, resulting in a greater speed.

20. If the pressure of a given gas is doubled while maintaining a constant temperature, what happens to the density of the gas and the speed of sound?
(A) Density halves; speed of sound doubles
(B) Density doubles; speed of sound remains constant
(C) Density remains constant; speed of sound doubles
(D) Density doubles; speed of sound is halved

Ans : (B)

When ambient pressure increases, the gas volume correspondingly decreases, but its total mass remains strictly constant. This causes the density to perfectly double. Since the ratio of pressure to density remains constant, the actual speed of sound is ultimately unaffected.

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21. Why does sound travel noticeably faster in humid air compared to completely dry air?
(A) The density of moist air is strictly greater than that of dry air
(B) The density of moist air is strictly less than that of dry air
(C) Humidity drastically increases the air pressure without affecting volume
(D) Humidity perfectly reduces the ambient temperature of the surrounding air

Ans : (B)

The speed of sound is directly proportional to the increase in humidity. The overall density of moist air containing unsaturated vapours is significantly less than the density of dry air. This lowered density predictably causes sound to travel much faster.

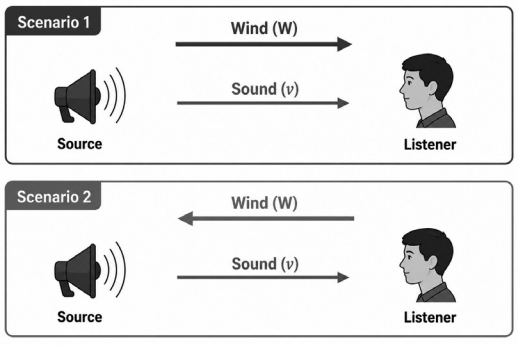
22. Match the terms in List-I with their correct characteristics in List-II.
List-I
P. Compression
Q. Rarefaction
R. Crest
S. Trough
List-II
I. Position of maximum downward displacement
II. Region of high pressure and low volume
III. Region of low pressure and high volume
IV. Position of maximum upward displacement
(A) P-II, Q-III, R-IV, S-I
(B) P-III, Q-II, R-I, S-IV
(C) P-II, Q-III, R-I, S-IV
(D) P-III, Q-II, R-IV, S-I

Ans : (A)

A compression is specifically a region possessing high pressure and low volume. A rarefaction features low pressure and high volume. In transverse waves, a crest represents maximum upward displacement, whereas a trough correctly indicates the maximum downward displacement position.

23. Which of the following properly pairs the physical quantity with its correct definition and SI unit?
(A) Frequency: Time taken to complete one vibration, Hertz

air is 'v'. How does the apparent speed of sound for the listener differ between Scenario 1 and Scenario 2?



(A) It is v + W in Scenario 1 and v - W in Scenario 2.
(B) It is v - W in Scenario 1 and v + W in Scenario 2.
(C) It is v in both scenarios, as wind does not affect sound speed.
(D) It is $\sqrt{(v^2 + W^2)}$ in both scenarios.

Ans : (A)

Explanation: The wind acts as a moving medium. When the wind blows in the same direction as the sound propagation (Scenario 1), its speed adds to the speed of sound, resulting in an effective speed of v + W. When it blows in the opposite direction (Scenario 2), it impedes the sound, resulting in an effective speed of v - W.

43. Match the animals in List-I with the specific type of sound they are noted to primarily produce or detect in List-II.
List-I
P. Elephants
Q. Bats
R. Dolphins
S. Grasshopper
List-II
I. Frequencies up to about 100 kHz
II. Infrasonic sounds less than 20 Hz
III. Frequencies typically from 90 Hz to 1.0 kHz
IV. Frequencies ranging from 200 Hz to 150 kHz
(A) P-II, Q-I, R-IV, S-III
(B) P-I, Q-II, R-III, S-IV
(C) P-II, Q-IV, R-I, S-III
(D) P-IV, Q-I, R-II, S-III

Ans : (A)

Elephants are known to produce infrasonic sounds effectively below 20 Hz. Bats can clearly hear ultrasound frequencies reaching up to 100 kHz. Dolphins communicate precisely between 200 Hz and 150 kHz, whereas grasshoppers operate distinctly between 90 Hz and 1.0 kHz.

44. Read the assertion and reason carefully, then choose the correct option.
Assertion (A) : Infrasonic waves can easily cover extremely long distances and successfully get around huge physical obstacles with very little dissipation.
Reason (R) : Infra-sound waves carry extraordinarily high amounts of energy strictly due to their incredibly high frequencies.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The assertion is genuinely true, as infra-sound can comfortably navigate enormous distances with minimal energy dissipation. The provided reason is fundamentally false, however, because infra-sound possesses significantly low frequencies and relatively long wavelengths, completely unlike highly energetic, high-frequency ultrasonic waves.

45. Even though the human ear strictly cannot hear infra-sound, what notable physiological or psychological effects can it actively induce in certain susceptible individuals?
(A) Spontaneous muscle cramps and high fever
(B) Complete temporary loss of eyesight
(C) Feelings of unexplained fear or depression
(D) Immediate and irreversible nerve damage

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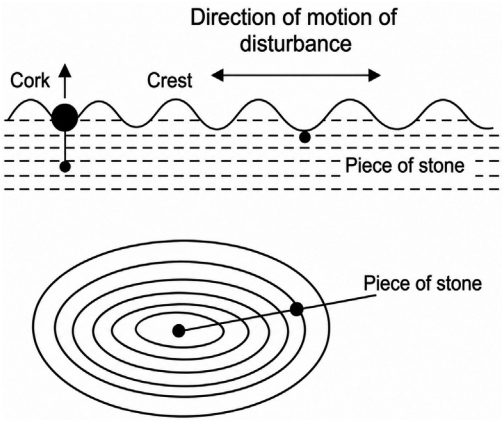
Ans : (C)

Even though we technically cannot hear infra-sound through our normal auditory senses, its subtle low-frequency vibrations can mysteriously induce profound feelings of deep psychological fear or strange depression in certain highly sensitive individuals exposed to these specific atmospheric waves.

46. Which of the following precisely defines an ultrasonic sound?
(A) A sound possessing a frequency strictly above 20,000 Hz
(B) An object physically travelling much faster than the standard speed of sound
(C) A sound wave with an extraordinarily low frequency below 20 Hz
(D) A highly destructive sound wave produced exclusively during powerful earthquakes

the fact that a disturbance is produced in water at the point where the stone strikes the water. This disturbance spreads in all directions radially outwards on the surface of water in the form of circular waves as shown in fig. below.



Place a piece of cork at some distance away from the point of striking the stone. It will be found that the cork does not move ahead but it vibrates up and down, while the wave moves ahead. It is because the particles of water start vibrating up and down at the point of striking of the stone. These vibrating particles then transfer energy to the other neighbouring particles. This process continues and the disturbance moves ahead on water surface in the form of waves as shown in Fig. This experiment proves that in wave motion, the energy is transferred but the particles of the medium do not move ahead.

96. Differentiate between infrasonic, sonic, ultrasonic and supersonic sounds.

Ans :

Infrasonic, sonic, ultrasonic, and supersonic sounds are different types of sound waves that are distinguished by their frequency and wavelength.

1. Infrasonic sounds: These are sounds that have a frequency lower than the human hearing range, which is typically considered to be 20 Hz to 20,000 Hz. Infrasonic sounds have a frequency of less than 20 Hz, and they are often produced by natural phenomena like earthquakes, volcanic eruptions, and thunder. Infra-sound can also be produced by man-made sources like aircraft and machinery.
2. Sonic sounds: These are sounds that are within the human hearing range and have a frequency between 20 Hz and 20,000 Hz. Sonic sounds are produced by many sources in our daily lives, such as people talking, music, and environmental sounds like wind, water, and animals.
3. Ultrasonic sounds: These are sounds that have a frequency higher than the human hearing range, which is above 20,000 Hz. Ultrasonic sounds are used in various applications, such as medical imaging, industrial testing, and cleaning. Animals like bats and dolphins also use ultrasonic sounds for echolocation.
4. Supersonic sounds: These are sounds that have a frequency higher than the sonic range, and their speed is greater than the speed of sound in the medium they are traveling through. Supersonic sounds are produced by objects that are moving faster than the speed of sound, like aircraft, rockets, and bullets.

In summary, the main differences between these types of sound are their frequency and the range in which they can be heard.

NUMERICAL QUESTIONS

97. A source of wave produces 40 crests and 40 troughs in 0.4 s. What is the frequency of wave ?

Ans :

Number of crests and troughs produced in 0.4s = 40 Number of crests and troughs produced in is $= \frac{40}{0.4} = 100$ i.e., Frequency of the wave = 100 Hz

98. The time period of a simple pendulum is 2 s. Find its frequency.

Ans :

$$n = \frac{1}{T} = \frac{1}{2}\text{s}^{-1}$$

$$= 0.5 \text{ s}^{-1} \text{ or } 0.5 \text{ Hz}$$

99. A boy fires a gun and another boy at a distance hears the sound of fire 2.5 s after seeing the flash. If speed of sound in air is 340 m/s, find distance

Ans :

$$\text{We know that Speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$\text{Distance} = \text{speed} \times \text{time}$$

$$= 2.5 \times 340$$

$$= 850 \text{ m}$$

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and sensitive receiver. The highly responsive receiver instantly produces either a high or deeply low auditory sound strictly depending upon the detected ultrasonic echo from nearby obstacles.

ONE MARK QUESTIONS

52. What causes sound ?

Ans :

Vibrations of a body causes sound.

53. What is the audible range of frequency for human?

Ans :

Hz to 20 kHz.

54. Complete the following sentence :
Sound is produced by a ..... body.

Ans :

Sound is produced by a vibrating body.

55. What is ultrasound ?

Ans :

The sound of frequency greater than 20000 Hz is called the ultrasound.

56. State the approximate speed of ultrasound in air.

Ans :

The speed of ultrasound in air is the same as that of sound i.e. 330 ms^{-1}

57. There is no atmosphere on moon. Can you hear each other on the moon's surface ?

Ans :

No, we cannot hear each other since sound requires medium for transmission. It cannot travel through vacuum.

58. For which range of frequencies, human ears are most sensitive?

Ans :

2000 Hz to 3000 Hz. In this range, the ears can hear even a very feeble sound.

59. Which has the higher frequency - ultrasonic sound or infrasonic sound ?

Ans :

Ultrasonic sound.

60. How does the speed of sound in air vary with temperature?

Ans :

Speed of sound increases by 0.6 ms^{-1} for every $1^\circ C$ increase in temperature.

61. Arrange the speed of sound in gases V_g, solids V_s and liquids V_l in an ascending order.

Ans :

Speed of sound in increasing order is : $V_g < V_l < V_s$

62. State the speed of (i) light and (ii) sound in air ?

Ans :

(i) Speed of light in air $= 3 \times 10^8$ ms^{-1}
(ii) Speed of sound in air = 330 ms^{-1} at $0^\circ C$

63. Name the two kinds of waves in form of which sound - travels in a medium.

Ans :

The two kinds of waves are :
(i) Longitudinal waves,
(ii) Transverse waves.

64. In which medium speed of sound is more : humid air or dry air ? Give a reason to your answer.

Ans :

Speed of sound is more in humid air than in dry air, because humid air is less denser than dry air (about 5/8th).

65. What do you mean by the term frequency of a wave ? State its S.I. unit.

Ans :

The number of vibrations made by a particle of the medium in one second is called frequency of the wave. Its S.I. unit is $second^{-1}$ or hertz (Hz).

66. Define the term wave velocity. Write its S.I. unit.

Ans :

The distance travelled by wave in one second is called wave velocity. S.I. unit : ms^{-1}

67. State two properties of medium on which the speed of sound in it depends.

Ans :

(i) The medium must be elastic.
(ii) The medium must have inertia.

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$$= \frac{1700}{340}\text{s} = 5\,\text{s}$$

(ii) Time taken by sound to travel a distance of 1700 m in water

$$= \frac{\text{Distance}}{\text{Velocity of sound in water}}$$

$$= \frac{1700}{1360}\text{s} = 1.25\,\text{s}$$

107. An observer sitting in line of two tanks, watches the flashes of two tanks firing at each other at the same time, but he hears the sounds of two shots 2 s and 3.5 s after seeing the flashes. If distance between the two tanks is 510 m, find the speed of sound.

Ans :

Let distance of first tank from the observer $= x_1$ metre

Distance of the second tank from the observer $= x_2$ metre

$$x_2 - x_1 = 510\,\text{m} \qquad ....(1)$$

Let speed of sound $= v\ \text{ms}^{-1} = ?$

Now, distance = speed × time

$$x_1 = v \times 2$$

and $$x_2 = v \times 3.5 = 3.5v$$

$$x_2 - x_1 = 3.5\,v - 2v$$

or $$510 = 1.5\ v$$

$$v = \frac{510}{1.5}\text{ms}^{-1} = 340\ \text{ms}^{-1}$$

CASE BASED QUESTIONS

108. Rohan and his friend participate in a field activity to determine the speed of sound using a direct experimental method. They stand on two separate hillocks separated by a straight linear distance of 850 m. Rohan fires a starting pistol into the air, while his friend starts a stopwatch upon seeing the flash and stops it upon hearing the gunshot. They record a precise time interval of 2.5 s for the acoustic disturbance to travel across the gap. They repeat the exact process several times by swapping the pistol and stopwatch to minimise environmental and personal errors.

(a) Calculate the speed of sound in air using the data recorded from the initial observation.

(b) State the formula used to calculate the speed of sound in a gas according to Laplace's correction and name the constant γ in it.

Ans :

(a) Speed of sound = Distance/Time

$$= 850\text{m}/2.5\text{s} = 340\text{ms}^{-1}$$

(b) 1. The formula used to calculate the speed of sound in a gas according to Laplace's correction is given by the relation $v = \sqrt{\gamma P/\rho}$.

2. In this specific equation, the constant γ represents the ratio of the specific heat of the gas at constant pressure to the specific heat at constant volume.

109. Rahul measures the speed of sound on a cold winter morning at 0°C and finds it to be 330 ms^{-1}. Later in the year, he conducts a similar outdoor acoustic experiment on a hot summer afternoon when the air temperature has risen to 35°C. He observes that acoustic signals reach his receivers faster during the summer experiment. He ensures that the specific gas composition of the air remains constant across both his observation sessions. His teacher explains that atmospheric conditions directly alter propagation speeds.

(a) Calculate the speed of sound in air during the summer afternoon at 35°C.

(b) State the exact relation between the speed of sound and the absolute temperature of a gas.

(c) State what happens to the speed of sound in the air if the frequency of the sound source is doubled during the experiment.

Ans :

(a) $v_t = v_0 + 0.61t$

$$\text{v}_\text{t} = 330\ \text{ms}^{-1} + (0.61\ \text{ms}^{-1^{\circ}}\text{C}^{-1} \times 35^{\circ}\text{C})$$

$$v_t = 351.35\ \text{ms}^{-1}$$

(b) The speed of sound is directly proportional to the square root of the absolute temperature of the gas, expressed by the relation $v \propto \sqrt{T}$.

(c) The speed of sound in the air remains completely unaffected and unchanged because the speed of sound is entirely independent of the frequency of the wave.

110. Anjali watches a distant thunderstorm from her apartment balcony on a rainy evening. She sees a bright flash of lightning illuminate the dark sky and immediately starts her digital stopwatch. She closely observes the storm and records the time elapsed until she hears the loud crash of thunder. Her stopwatch reads exactly 6.0s when the

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Ans :

Speed of sound $V = \sqrt{\frac{\gamma P}{d}}$.

The relation does not contain amplitude and wavelength.
So
(a) Amplitude has no effect on speed of sound.
(b) Wavelength has no effect on speed of sound.

80. State three characteristics of the medium required for propagation of sound ?

Ans :

Three characteristics of medium required are :
(1) Medium must have the inertia so that its particles have capacity to store the energy.
(2) Medium must be elastic so that medium particles have the tendency to return back to their positions after the displacement.
(3) The medium must be frictionless.

81. Explain meaning of the terms compression and rarefaction in relation to a longitudinal wave.

Ans :

A compression is that part of a longitudinal wave in which the particles of the medium are closer to one another than they normally are, and there is a momentary reduction in volume of the medium. A rarefaction is that part of a longitudinal wave in which the particles of the medium are farther apart than normal, and there is a momentary increase in the volume of the medium.

THREE MARKS QUESTIONS

82. Can you hear the sound produced due to vibrations of a seconds pendulum ? Give reason.

Ans :

No; because the frequency of the sound produced due to the vibrations of a second's pendulum is

$$n = \frac{1}{T} = \frac{1}{2} Hz = 0.5\, Hz,$$

Which is less than 20 Hz. (The audible range of frequency is from 20 Hz to 20,000 Hz).

83. Answer the following :
(i) Can sound travel in vacuum ?
(ii) How does the speed of sound differ in different media ?

Ans :

(i) No, sound waves cannot travel in vacuum.
(ii) Speed of sound is about 330 ms^{-1} in air. It is about 1450 ms^{-1} in water and 5100 ms^{-1} in steel.
In other words speed of sound is different in different media. It is more in solids, less in liquids and least in gas. Since solids are much more elastic than liquid and gases.

84. Complete the following sentences :
(a) An average person can hear sound of frequencies in the range ..... to ..... .
(b) Ultrasound is of frequency ..... .
(c) Infrasonic sound is of frequency ..... .
(d) Bats can produce and hear ..... .sound.
(e) Elephants produce ..... . sound.

Ans :

(a) 20 Hz, 20 kHz
(b) above 20 kHz,
(c) below 20 Hz
(d) ultrasonic,
(e) infrasonic.

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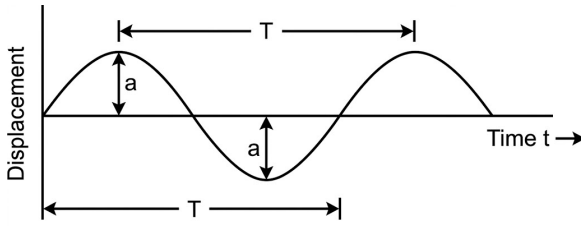
85. Draw displacement-time graph of a wave and show on it the amplitude and time period of wave.

Ans :

The figure given below shows the amplitude and time - period of a wave on displacement - time graph. The amplitude is represented by the letter a and time-period is represented by the letter T.



Displacement-time graph of a particle of a wave

86. Draw a displacement-distance graph of a wave and mark on it, the amplitude of wave by the letter a and wavelength of wave by the letter A,.

Ans :

The figure given below shows the displacement-distance graph of a wave in which amplitude of the wave is shown by the letter a and wavelength is shown by the letter λ.

68. Compare approximately the speed of sound in air, water and steel.

Ans :

Speed of sound in air, water and steel is 330 ms^{-1}, 1450 ms^{-1} and 5100 ms^{-1} i.e. 4 times in water and 15 times in steel.

69. Define the term amplitude of a wave. Write its S.I. unit.

Ans :

The maximum displacement on one side of the mean position of a particle of medium is called amplitude of the wave. It S.I. unit is meter (m).

70. How is the frequency of a wave related to its time period?

Ans :

The frequency (v) of a wave is equal to the reciprocal of its time-period (T). i.e. $v = \frac{1}{T}$

71. Flash of lightning reaches us earlier than the sound of thunder. Explain the reason.

Ans :

Flash of light reaches earlier than sound of thunder, Since velocity of light is 3×108 ms^{-1} whereas velocity of sound is only 330 ms^{-1}.

72. If you place your ear close to an iron railing which is tapped some distance away, you hear the sound twice. Explain why ?

Ans :

First we hear the sound which is travelling about 16 times fast in the iron railing and then second sound which is travelling at about 330 ms^{-1} in air. Thus, we hear two sounds.

73. What is a longitudinal wave ? In which medium — solid, liquid or gas, can it be produced ?

Ans :

The wave in which the particles of the medium vibrate about their mean positions in the direction of propagation of sound is called longitudinal wave. Such a wave can be produced in solids, liquids as well as gases.

74. Choose the correct word/words to complete the following sentence :
When sound travels in a medium ..... (the particles of the medium, the source, the disturbance, the medium) travels in form of a wave.

Ans :

the disturbance

75. What is a transverse wave ? In which medium — solid, liquid or gas, can it be produced ?

Ans :

The wave in which the particles of the medium vibrate about their mean positions in a direction perpendicular to the direction of propagation of the wave is called transverse wave. Such a wave can be produced in solids and on the surface of liquids.

76. What do you mean by audible range of frequency?

Ans :

The human ear is able to hear sound in a frequency range of about 20 Hz to 20000 Hz. Therefore, the audible range of frequency for an average person is 20 Hz to 20 kHz i.e., we cannot hear sounds of frequencies less than 20 Hz or more than 20 kHz.

77. State two properties of ultrasound that make it useful to us.

Ans :

(i) The energy carried by the ultrasound is very high.
(ii) The ultrasound can travel along a well defined straight path. It does not bend appreciably at the edges of an obstacle.

TWO MARKS QUESTIONS

78. Explain how do bats locate obstacle and prey in their way.

Ans :

Bats avoid obstacles in their way by producing ultrasound. They emit ultrasound which return back after striking an obstacle in their way. But hearing the reflected sound and from the time interval (when they produced ultrasound and they received them back) they can judge the distance of obstacle in their way.

79. How does the speed of sound change with change in (i) amplitude and (ii) wavelength, of sound wave ?

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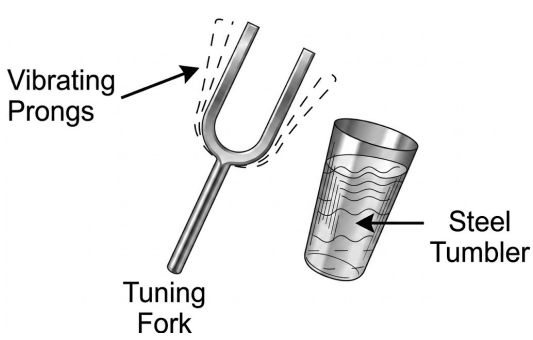
92. (a) What is sound ? How is it produced ?
(b) Describe a simple experiment which demonstrates that the sound produced by a tuning fork is due to vibrations of its arms.

Ans :

(a) Sound is a form of energy that produces the sensation of hearing in our ears. Sound is produced when a body vibrates.
(b) Experiment. Take a tuning fork. Strike its arms with a rubber pad. You will hear a sound and edges of the fork blurred due to vibrations. If you bring slightly close to a tumbler of steel (near its edge) a clinking (Trembling of tumbler) sound is produced. This shows that arms of tuning fork are vibrating. When its arms stop vibrating, no sound is heard. Thus, the vibrations of arms of tuning fork produce sound.



93. Describe a simple experiment to determine the speed of sound in air. What approximation is made in the method described by you ?

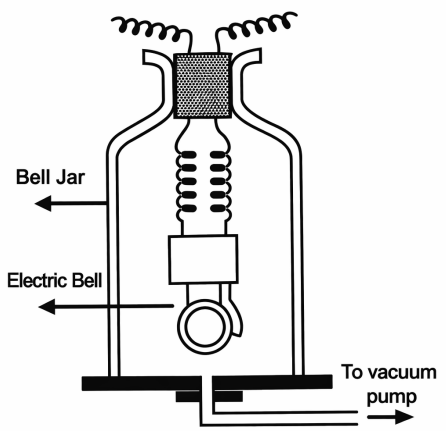
Ans :

The fact that light travels in air about a million times faster than sound, can be used to determine the speed of sound in air.
Experiment : Choose two places A and B at a known distance 'd' apart (say about 1 km or more) in free air. At each place, there is an observer with a gun and a stop-watch. The observer at A fires the gun. The observer at B starts his stop watch when he sees the flash of the fire and stops it when he hears the sound of the fire. The time interval t, is noted. Now the observer at B fires the gun and observer at A starts his' stop-watch when he sees the flash of the fire and stops it when he hears the sound of fire. The time interval t_2 is noted.
The average of the two time intervals is $t = \frac{t_1+t_2}{2}$
This is time taken by the sound to travel from A to B. The speed of sound is then calculated by using the formula : $V = \frac{\text{distance}}{\text{time}} = \frac{d}{t} \text{ms}^{-1}$
In this experiment, the time interval for sound to travel from A to B and then from B and A are measured so as to remove the error arising due to flow of wind. However, the speed of sound so determined is not very accurate because of the personal errors of the observer and variation in temperature and humidity of air between the places A and B.

94. Describe in brief, with the aid of a labelled diagram, an experiment to demonstrate that a material medium is necessary for the propagation of sound.

Ans :

To demonstrate that material medium is necessary to transmit sound.
Experiment. — (Bell - jar Experiment). Take a glass bell - jar connected to vacuum pump and containing electric bell as shown in the figure. As the electric bell circuit is completed, the sound is heard. Now remove air from inside the bell-jar with the help of vacuum pump. The sound decreases and finally no sound is heard when all the air has been removed, but the hammer still seen striking repeatedly. If we again fill air in bell-jar, sound becomes louder again. This shows that sound requires a material medium for transmission.



95. Describe an experiment to show that in wave motion, only energy is transferred, but the particles of medium do not leave their position.

Ans :

Drop a piece of stone in still water of a pond. Water at the point of striking the stone will start vibrating and a sound will be heard. It is due to

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Ans : (A)

Ultrasonic sound, fundamentally known as ultrasound, is precisely defined as acoustic energy possessing a frequency strictly exceeding 20,000 Hz. This specific range notably lies comfortably higher than the maximum upper audible limit perceivable by a normal, healthy human ear.

47. What is the fundamental difference between the specific terms 'ultrasonic' and 'supersonic'?
(A) Ultrasonic refers strictly to high-frequency sound, while supersonic describes objects moving faster than sound
(B) Ultrasonic defines very high-speed jets, while supersonic refers strictly to extremely high-frequency vibrations
(C) Ultrasonic waves do not require a material medium, whereas supersonic waves clearly do
(D) There is absolutely no difference; both accurately describe very high-speed sound waves

Ans : (A)

The specialised term ultrasonic strictly refers to actual sound waves possessing a frequency entirely above 20 kHz. Conversely, the term supersonic is specifically used to classify solid objects that physically travel at a velocity exceeding the speed of sound.

48. Which of the provided statements accurately describe the physical properties of ultrasound waves?
I. They carry an exceptionally high amount of energy.
II. They safely travel along a very well-defined straight path.
III. They readily bend around tiny physical obstacles due to low frequency.
IV. They possess an extremely long wavelength compared to audible sound.
(A) I and IV (B) I and II
(C) II and III (D) III and IV

Ans : (B)

Ultrasound waves are structurally characterised by highly elevated frequencies, which means they distinctly carry substantial amounts of energy. Furthermore, their comparatively small wavelengths strictly enable them to travel undisturbed in perfectly well-defined straight paths without bending around physical obstacles.

49. Why are ultrasonic transducers considered highly crucial in the modern medical field of sonography?
(A) They safely destroy heavy infectious bacteria directly within the active human bloodstream
(B) They perfectly align deeply fractured human bones back into their strict original position
(C) They successfully create accurate diagnostic images of a developing foetus safely inside the womb
(D) They routinely cure all major types of internal viral infections almost instantly

Ans : (C)

Ultrasonic transducers are completely indispensable in modern medical diagnostics because they precisely emit and capture high-frequency sound waves. This technology successfully creates highly detailed, non-invasive images of internal biological structures, such as a fragile developing foetus located inside the womb.

50. In which of the following specialised industrial processes is ultrasound actively and effectively employed?
(A) Extracting thick natural crude oil from completely dry underground reservoirs
(B) Cutting, welding, and thermofixing complex metallic and synthetic materials
(C) Melting exceptionally heavy solid iron blocks into pure liquid metal
(D) Generating highly volatile chemical reactions inside heavily sealed laboratory containers

Ans : (B)

Due to their significantly high concentrated energy and beautifully defined straight paths, ultrasound waves are actively and extensively employed in highly precise industrial processes. These demanding processes distinctly include critical tasks such as precision cutting, intricate welding, thermofixing and delicate embossing.

51. How do specialised ultrasonic glasses effectively assist visually impaired individuals in successfully navigating their immediate surroundings?
(A) They actively project bright guiding light beams directly onto a nearby solid pavement
(B) They perfectly map physical surroundings by sending complex visual signals into the brain
(C) They quickly produce distinctly varying sounds based on ultrasonic echoes returning from nearby objects
(D) They automatically steer the visually impaired individual away from all rapidly moving mechanical vehicles

Ans : (C)

These cleverly designed ultrasonic spectacles are fully equipped with a specialised tiny transmitter

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100. The time interval between a lightning flash and the first sound of thunder is 5 s. If the speed of sound in air is 330 ms^{-1}, find the distance of flash from the observer.

Ans :

Here, $t = 5\,s$

Speed of sound $V = 330\,ms^{-1}$

Distance of the flash from the observer

$$d = V \times t$$

Distance $= 330 \times 5$

$= 1650\,m$

101. The heart of a man beats 75 times a minute. What is its (a) frequency and (b) time period ?

Ans :

(a) Number of times, the heart beats in 1 minute or 60 seconds = 75

Number of times, the heart beats in one second

i.e., frequency of the heart,

$$n = \frac{75}{60} s^{-1}$$

$$= 1.25 s^{-1}$$

(b) Time-period of the heart,

$$T = n = \frac{1}{n} = \frac{1}{1.25} = 0.8 s$$

102. The separation between two consecutive crests in a transverse wave is 100 m. If wave velocity is 20 m s^{-1}, find the frequency of wave.

Ans :

Here, $\lambda = 100\,m$

$v = 20\,ms^{-1}$

$n = ?$

Using $v = n\lambda$, we have

$$n = \frac{v}{\lambda} = \frac{20}{100}$$

$$Hz = 0.2\ Hz$$

103. A longitudinal wave travels at a speed of 0.3 m s^{-1} and the frequency of wave is 20 Hz. Find the separation between the two consecutive compressions.

Ans :

Given ,$v = 0.3\ ms^{-1}$; $n = 20$ Hz

Let separation between two consecutive compressions i.e. wave-length of the wave = 1

Using $v = n\lambda$, we have

$$\lambda = \frac{v}{n}$$

$$= \frac{0.3}{20} m$$

$$= 1.5 \times 10^{-2} m$$

$= 1.5$ cm.

104. An observer A fires a gun and another observer B at a distance 1650 m away from A hears its sound. If the speed of sound is 330 m s^{-1}, find the time when B will hear the sound after firing by A.

Ans :

Distance to be travelled by sound = 1650 m

Velocity of sound = 3330 ms^{-1}

$$Time = \frac{destance}{velocity}$$

$$= \frac{1650}{330} s = 5\ s$$

Time after which B will hear the sound after firing by A = 5 s

105. How long will sound take to travel in

(a) an iron rail and

(b) air, both 3.3 km in length ?

Take speed of sound in air to be 330 ms^{-1} and in iron to be 5280 ms^{-1}

Ans :

Distance to be travelled by sound = 3.3 km = 3300 m Time taken by sound to travel in iron rail

$$= \frac{Distance}{Velocity\ of\ sound\ in\ iron}$$

$$= \frac{3300}{5280} s = 0.625\,s$$

Time taken by sound to travel in air

$$= \frac{Distance}{Velocity\ of\ sound\ in\ air}$$

$$= \frac{3300}{330} s = 10\,s$$

106. Assuming the speed of sound in air equal to 340 m s^{-1} and in water equal to 1360 m s^{-1}, find the time taken to travel a distance 1700 m by sound in (i) air and (ii) water.

Ans :

(i) Time taken by sound to travel a distance of 1700 m in air

$$= \frac{Distance}{Velocity\ of\ sound\ in\ air}$$

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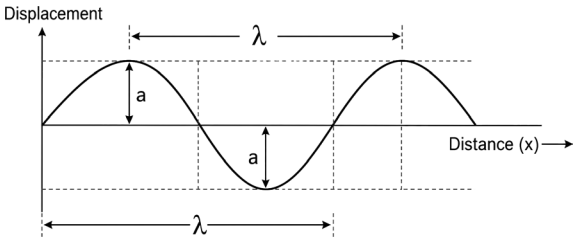


Displacement-distance graph of a wave

87. The sound of an explosion on the surface of a lake is heard by a boat man 100 m away and by a diver 100 m below the point of explosion.
(i) Who would hear the sound first : boat man or diver.
(ii) Give a reason for your answer in part (i).
(iii) If sound takes time t to reach the boat man, how much time approximately does it take to reach the diver ?

Ans :

(i) Diver would hear the sound first.
(ii) Because sound travels at 1450 ms^{-1} (about 4 times the speed of sound in air 330 ms^{-1}).
(iii) If boatman hears sound after t seconds.
The diver will hear after $\frac{t}{4}s$ i.e. 0.25 t
Sound travels about 4 times faster in water.

88. Complete the following sentences :
(a) Sound cannot travel through ....., but it requires a ..... .
(b) When sound travels in a medium, the particles of medium ..... but the disturbance .....
(c) A longitudinal wave is composed of compression and ..... .
(d) A transverse wave is composed of crest and .....
(e) Wave velocity = ... × wavelength.

Ans :

(a) vacuum, medium,
(b) do not move, moves
(c) rarefaction,
(d) trough
(e) frequency.

89. State two applications of ultrasound.

Ans :

(i) For drilling holes or making cuts of desired shape in materials like glass, ultrasound is used.
(ii) For cleaning very small objects such as the parts of watches and electronic components.
(iii) For detection of defects in metals, ultrasound is used.
(iv) For imaging the human organs : Ultrasonography is used to obtain the images of patient's organs such as liver, gall bladder, uterus etc. Echo cardiography is used to obtain the image of the heart.
(v) In surgery to remove cataract and to break the small stones, into fine grains, formed in kidneys.
(vi) In sonar to detect and find the distance of objects under water.

90. Explain with an example the propagation of sound in a medium.

Ans :

When a source of sound vibrates, it creates a disturbance in the medium near it i.e. the condition of the medium near the source changes from its normal condition. This disturbance then travels in the medium.
Example : If we strike a tuning fork, both its prongs will start vibrating to and fro about their mean position. As the prong moves forward (towards right), it compresses the layer of air in front of it. The compressed layer moves forward and in turn compresses the next layer of air in front of it. Thus a wave of compression travels through air.
Now when the prong moves back (towards left), the particles of the medium move backward due to elasticity. Thus a wave of rarefaction is sent in the backward direction. In this manner as the prong moves to the right and left repeatedly, compressions and rarefactions are produced one after the other which carry the disturbance with it. This is how sound travels in a medium.

FOUR MARKS QUESTIONS

91. How do the following factors affect, if at all, the speed of sound in air :
(i) frequency of sound,
(ii) temperature of air,
(iii) pressure of air,
(iv) moisture in air ?

Ans :

(i) Speed of sound is independent of frequency of sound.
(ii) Temperature : Speed of sound increases with increase in temperature.
(iii) Pressure has no effect on speed of sound.
(iv) Moisture : increases speed of sound.

booming noise finally reaches her ears. She then compares the fundamental propagation properties of the two different waves travelling towards her from the distant storm clouds.

(a) State the speeds of light and sound in air and compare them to explain why the sound of thunder is heard after the flash of lightning is seen.

(b) Name the medium required for light waves to propagate from the clouds to the observer.

(c) State one difference between the wave types of light and sound propagating through the air.

Ans :

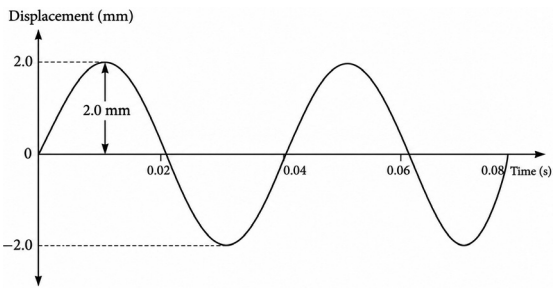
(a) 1. The speed of light in air is $3 \times 10^8 \text{ms}^{-1}$, while the speed of sound in air is comparatively much slower, being nearly 330 ms^{-1}.

2. Because light travels about a million times faster than sound, the lightning flash reaches the observer almost instantaneously, whereas the sound wave takes considerably more time.

(b) Light waves are non-mechanical waves that do not require any material medium for their propagation, meaning they can travel effortlessly through a complete vacuum.

(c) Light waves are transverse electromagnetic waves that travel without a medium, whereas the sound waves propagating in air are strictly longitudinal mechanical waves requiring a medium.

111. Divya studies the graphical representation of a wave passing through a specific medium. She analyses how the medium's particle shifts over consecutive seconds. The horizontal axis represents the total elapsed time in seconds, while the vertical axis tracks the instantaneous position. Divya extracts numerical parameters directly from the coordinates of the repeating sine curve.



(a) Determine the time period of the wave from the provided graphical data.

(b) Calculate the frequency of this wave in Hz.

(c) State the amplitude of the wave with its proper SI unit.

(d) Name the term used to describe the state of motion of the body with respect to its position and direction of motion at any instant on this graph.

Ans :

(a) By observing the exact point where the continuous curve completes one full symmetrical loop on the horizontal axis, the time period is determined as $0.04s$.

(b) $$f = 1/T$$
$$f = 1/0.04s$$
$$f = 25Hz$$

(c) Measuring directly from the central baseline to the top edge of the first peak, the maximum displacement or amplitude of the wave is exactly $0.002\,m$.

(d) The specific scientific term used to accurately determine the state of motion of the body with respect to its position and direction at any instant is phase.

112. Meera sets up an airtight glass enclosure in the school physics laboratory. She suspends a battery-operated electric alarm inside the enclosure using rubber bands and connects it to a power source. She turns on the alarm and clearly hears the continuous ringing noise propagating through the contained air. She then connects a heavy-duty motorized vacuum pump to the bottom outlet of the enclosure and switches it on. As the pump gradually extracts the air from the interior over ten minutes, she continuously observes the metallic hammering mechanism hitting the gong.

(a) Describe what happens to the loudness of the sound as the air is progressively extracted, and give one reason for this observation.

(b) Give one reason why the hammer is still seen striking the gong even when the entire air from the enclosure has been taken out.

Ans :

(a) 1. The loudness of the sound continuously goes on decreasing as the air is withdrawn from the bell jar, and finally, no sound is heard at all.

2. This observation clearly explains that sound requires a material medium to travel and it cannot propagate through a vacuum because it relies on mechanical vibrations.

(b) 1. The electrical circuit of the bell remains

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constant magnitude over time.
(C) Alternating current periodically reverses its flow direction back and forth.
(D) Alternating current exclusively originates from standard electrochemical dry cells.

Ans : (C)

Direct current maintains a constant magnitude and always flows unidirectionally through a given circuit. Conversely, alternating current periodically reverses its flow direction and alters its magnitude, making it the standard highly efficient form of electrical power supplied to domestic households.

11. Match the specific submultiples and multiples of the ampere in List-I with their correct numerical equivalent in List-II.
List-I
P. milli-ampere
Q. micro-ampere
R. kilo-ampere
S. mega-ampere
List-II
I. 103 A
II. 10^{-6} A
III. 10^{6} A
IV. 10^{-3} A
(A) P-IV, Q-II, R-I, S-III
(B) P-II, Q-IV, R-III, S-I
(C) P-I, Q-III, R-IV, S-II
(D) P-IV, Q-I, R-II, S-III

Ans : (A)

Smaller measuring units of current are heavily utilized for weak circuits, where a milli-ampere equals a thousandth of an ampere and a micro-ampere is one-millionth. Conversely, larger industrial currents employ kilo-amperes and mega-amperes representing thousands and millions of amperes respectively.

12. Read the given assertion and reason carefully, then choose the correct option strictly from the choices below.
Assertion (A) : Secondary cells are highly economical and generally preferred for extensive use in modern automobiles.
Reason (R) : The electrochemical reactions taking place inside secondary cells are completely reversible upon recharging.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

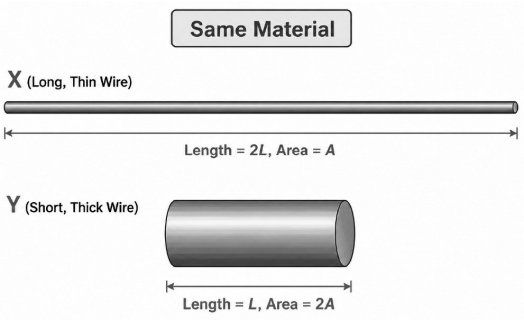
Secondary cells can be recharged successfully multiple times because their internal electrochemical reactions are entirely reversible. This distinct ability to securely store and reuse electrical energy makes them highly cost-effective over long periods and practically indispensable for heavy automobile applications.

13. How is the true direction of electronic current scientifically established in a metallic conductor?
(A) From a positively charged body to a negatively charged body
(B) Exactly along the directional path of positive ions
(C) From a negatively charged body to a positively charged body
(D) Perpendicular to the directional movement of passing free electrons

Ans : (C)

The precise direction of real electronic current is always determined by the actual movement of negatively charged electrons. They physically travel from a negatively charged body possessing excess electrons toward a positively charged body showing a comparative deficit of electrons.

14. Two wires, X and Y, are made of the same material (e.g., copper). Wire X is twice as long as wire Y, but has half the cross-sectional area. How does the resistance of wire X (R_X) compare to the resistance of wire Y (R_Y)?



(A) $R_x = R_y$
(B) $R_x = 2\ R_y$
(C) $R_x = 4\ R_y$
(D) $R_x = R_y / 4$

Ans : (C)

Explanation: The resistance of a wire is given by $R = \rho(l/A)$, where ρ is resistivity, l is length, and

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above 20 kHz to detect objects underwater.

(d) State one characteristic property of the waves emitted by bats that makes them useful for directional navigation.

Ans :

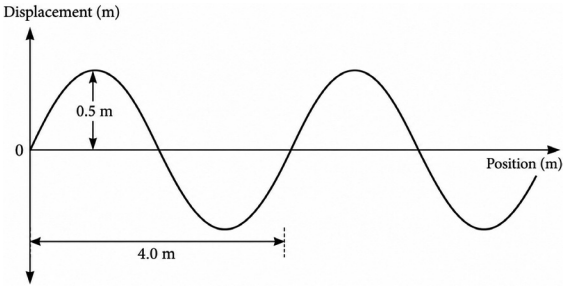
(a) The specific category of low-frequency sound produced by the elephants at 15 Hz is scientifically known as infrasonic sound or simply referred to as infra sound.

(b) The standard audible range of frequencies that can be successfully perceived by a normal human ear strictly spans from about 20 Hz up to 20,000 Hz.

(c) The specialized technological system that extensively utilizes sound frequencies above 20 kHz to securely detect and find the distance of objects underwater is called SONAR.

(d) Ultrasound beams possess incredibly high frequencies that allow them to be highly directional, ensuring they remain completely undisturbed while travelling perfectly over very long distances.

116. Arjun investigates the mathematical representation of transverse wave motion using an oscilloscope. He plots a physical property of the wave against the distance it travels through a continuous medium. The velocity of the propagating disturbance is recorded as 320 ms^{-1} . He uses the graphical data to calculate the corresponding wave characteristics.



(a) Read the amplitude and wavelength from the graph.

(b) Calculate the frequency of the wave using the values obtained from the graph and the given velocity.

(c) Name the specific physical quantity plotted on the vertical axis for this type of graph.

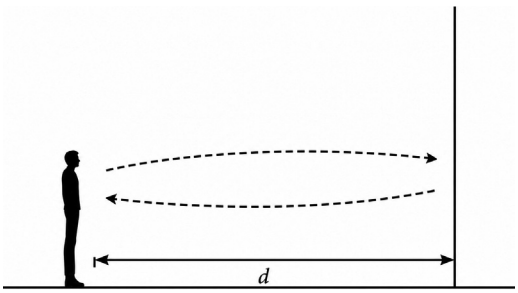
Ans :

(a) By carefully analyzing the provided graphical data, the amplitude of the wave is 0.5 m and the complete wavelength of the single cycle is 4.0 m.

(b) $$\text{Frequency} = \frac{\text{Wave velocity}}{\text{Wavelength}}$$
$$= 320\ ms^{-1}/4.0\text{m}$$
$$= 80\text{Hz}$$

(c) The specific physical quantity plotted on the vertical axis for this transverse wave representation is displacement, showing the variation of medium particles from their mean positions.

117. Priya stands near a tall vertical structure to perform an acoustic reflection experiment. She holds a wooden clapper and produces a sharp impulsive noise. She records the time interval until she perceives the returning noise. The velocity of the acoustic waves in the surrounding air is 340 ms^{-1}



(a) Calculate the distance d to the vertical structure if Priya records a time interval of $1.5s$ for the returning noise.

(b) Name the specific phenomenon representing the returning noise that Priya records.

(c) State one atmospheric factor that can bring personal errors in noting time intervals during this experiment.

Ans :

(a) $$\text{Distance} = \frac{(\text{Speed} \times \text{Timetaken})}{2}$$
$$= \frac{(340 ms^{-1} \times 1.5s)}{2} = 255\text{ m}$$

(b) The specific acoustic phenomenon representing the returning noise that Priya records after the sound reflects from the distant vertical structure is clearly known as an echo.

(c) One atmospheric factor that can bring personal errors and significantly alter the recorded time intervals during this outdoor acoustic reflection experiment is the direction of wind.

118. Aditya investigates the fundamental source of acoustic energy in the physics laboratory. He

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8. ELECTRICAL RESISTANCE

There is always some obstruction in the current which flows through a conductor such as a metal wire, and this obstruction is called its electrical resistance.

According to Ohm's law, if current I flows through a wire when potential difference across the ends of a wire is V, then the resistance offered by the wire is Resistance (R)

$$= \frac{\text{Potential difference across the wire (V)}}{\text{Current flowing in the wire (I)}}$$

1. When conductors are joined in series, the resistance increases.
2. When conductors are joined in parallel, their combined resistance decreases.
3. The SI unit of resistance is ohm (Ω), or it is also written as volt per ampere.
4. The resistance of a conductor is said to be one ohm if a current of one ampere flows through it when the potential difference across it is one volt.

8.1 Resistance of a Wire Depends on Four Factors

The resistance of the wire depends on the following factors :

1. Length of the wire:
   Resistance (R) $\propto$ length (l)
2. Thickness of the wire:
   $$\text{Resistance (R)} \propto \frac{1}{\text{Area of cross} - \text{section (A)}}$$
3. Material of the wire: The resistance depends on the material of the wire as there is different concentration and different arrangement of atoms in different materials.
4. Temperature of the wire: A higher temperature of the wire causes the ions in it to vibrate more rapidly. As a result, the number of collisions increases, and hence, the resistance increases.

OBJECTIVE QUESTIONS

1. Which crucial measuring instrument must intentionally maintain a significantly high internal resistance to function appropriately?
(A) Standard tapping key
(B) Conductive copper wire
(C) Standard ammeter
(D) Standard voltmeter

Ans : (D)

A voltmeter functions as a crucial measuring device intended to determine the exact potential difference between two separate points. To ensure accurate continuous measurement without drawing significant current from the main conducting path, it consistently utilizes remarkably high internal resistance.

2. The work done in moving a certain amount of charge between two points in a circuit is measured in four different trials. In which trial is the potential difference between the two points the greatest?

Trial	Work Done (W) (J)	Charge Moved (q) (C)
1	18	3
2	24	6
3	45	3
4	20	5

(A) Trial 1
(B) Trial 2
(C) Trial 3
(D) Trial 4

Ans : (C)

Potential difference (V) is calculated as the work done per unit charge (V = W/q). For Trial 3, V = 45 J / 3 C = 15 V. The potential differences for Trials 1, 2, and 4 are 6 V, 4 V, and 4 V, respectively. The greatest value is 15 V, corresponding to Trial 3.

3. What precisely defines an electric current within a solid metallic wire?
(A) The accumulation of stationary static charges
(B) The continuous rate of flow of electric charge
(C) The total resistance offered by the metallic wire
(D) The chemical reactions occurring inside the battery

Ans : (B)

Electric current refers to the continuous rate of flow of electric charge through a specific cross-sectional area of a metallic conductor. This essential flow of electrons establishes the foundation for transferring electrical energy effectively across various connected circuit components in appliances.

4. If exactly nine continuous joules of mechanical work are strictly required to transfer precisely one point five coulombs of electric charge, what is the exact potential difference?

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CHAPTER 9

Current Electricity

SUMMARY

1. SOURCES OF DIRECT CURRENT

The regular pencil cells used in daily life provide a direct current. The direct current is a current of constant magnitude flowing in one direction.
In a cell, chemical energy changes into electrical energy when it sends current in the circuit.

2. KINDS OF CELLS

Cells are of two kinds which are as follows :

2.1 Primary cells

These cells provide current as a result of an irreversible chemical reaction. They are called 'use and throw' cells. Depending on the material of the electrodes and electrolyte, we have different types of primary cells such as simple voltaic cell, Leclanche cell, Daniel cell and dry cell.

2.2 Secondary cells or accumulators

These cells also provide electrical energy by using up chemical energy stored in them, but they can be recharged after use.

1. Lead (or acid) accumulator and Ni—Fe (or alkali) accumulator are the two types of secondary cells.
2. These cells are also called storage cells.

Primary cell	**Secondary cell**
Chemical reaction is irreversible	Chemical reaction is reversible.
Chemical energy is converted into Electrical energy	Electrical energy changes to chemical energy passed in it, while chemical energy when current is changes to electrical energy when current is drawn from it.
It cannot be recharged.	It can be recharged.
It is capable of providing weak current only.	It can provide small and large currents
It is light and cheap.	It is heavy and costly.
Examples: Simple voltaic cell, Daniel cell	Examples: Lead accumulator, Ni - Fe accumulator

3. ELECTRIC CURRENT

The current is the rate of flow of charge across a cross-section which is normal to the direction of flow of current.

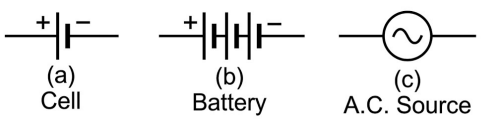
$$\text{Current (I)} = \frac{\text{Charge}\,(Q)}{\text{Time}\,(t)}$$

1. It is a scalar quantity.
2. Its SI unit is ampere (A).
3. Current is one ampere if the rate of flow of charge is one coulomb per second.
4. Conventionally, the direction of current is taken in the direction of flow of positive charge. This direction is opposite to the direction of flow of electrons.

3.1 Symbols used in Circuit Diagrams

A circuit has various electric components.
Sources of current: Current is of two types—alternating (or AC) and direct (or DC). AC is obtained from the mains in our house or an AC generator, while DC is obtained from a cell or battery.

1. A cell giving direct current is represented by two vertical lines of unequal lengths.
2. When a large current is needed, several cells are joined together in series with the cathode of one cell connected to the anode of another to form a battery.



Symbolic representation of source of current

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completely intact and functional even when the air is continuously removed by the connected vacuum pump.

2. The internal hammer continues vibrating to produce sound energy by striking the gong repeatedly, but this mechanical energy cannot travel outwards without any surrounding air particles.

113. Karan conducts theoretical research on how different atmospheric factors influence the propagation of sound waves in the environment. He reviews experimental data tables recording the speed of sound under varying meteorological conditions. He notes that the reference speed in dry air at standard temperature and pressure is $330\ ms^{-1}$. He then analyses how deliberate changes in atmospheric pressure, moisture content, and wind direction alter this base velocity. His analysis requires applying fundamental acoustic laws to predict the exact variations in wave propagation.

(a) State what happens to the speed of sound in the air if the atmospheric pressure is doubled while temperature remains constant.

(b) Compare the density of moist air with the density of dry air at ordinary temperatures.

(c) State what happens to the speed of sound when wind is blowing in a direction opposite to the direction of propagation of sound.

(d) Name the term used to describe the propagation of sound where there is no exchange of heat in the medium.

Ans :

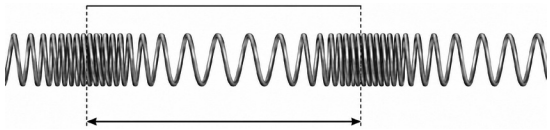
(a) The speed of sound in the gas remains entirely unchanged because the speed of sound is completely independent of any variations in the atmospheric pressure.

(b) The density of moist air containing unsaturated vapours is strictly less than the density of dry air when measured at ordinary temperature conditions in the atmosphere.

(c) When the wind is blowing in a direction strictly opposite to the direction of sound propagation, the overall speed of the propagating sound gets decreased.

(d) The term used to describe the propagation of sound where there is absolutely no exchange of heat within the medium is known as an adiabatic change.

114. Manish conducts a laboratory demonstration to visualize the propagation mechanism of mechanical disturbances through a solid medium. He uses a long, flexible metallic coil placed on a smooth horizontal table. He attaches one end to a fixed support and oscillates the free end forward and backward at a constant rate, observing the changing density of the metallic turns.



(a) Name the two specific regions formed by the alternating spacing of the coil loops and state how the pressure in the medium varies across these two regions.

(b) Name the type of wave demonstrated by this coil and give one reason why liquids and gases can only transmit this specific type of wave.

Ans :

(a) 1. The segment where the individual circular loops are packed very close together is known as a compression, which intrinsically represents a distinct region of high pressure.

2. The segment where the adjacent loops are spread wide apart is known as a rarefaction, which intrinsically represents a distinct region of low pressure in the medium.

(b) 1. The specific type of mechanical wave successfully demonstrated by the alternating spacing of loops in this metallic coil is uniformly referred to as a longitudinal wave.

2. Liquids and gases can exclusively transmit longitudinal waves because they cannot restore all the forces, as their lack of rigidity makes it impossible to restore forces in all directions.

115. Sneha is fascinated by the hearing capabilities of different living organisms and reads a biology journal detailing how animals communicate over long distances. She notes that bats emit signals at 120 kHz to navigate safely in the dark without hitting obstacles. She also learns that elephants produce low-rumbling calls at 15 Hz to coordinate with their herds across vast grasslands. She compares these biological frequencies with the normal auditory capabilities of human beings. She then researches how scientists artificially generate these specific animal frequencies for technological applications.

(a) Name the specific category of sound produced by the elephants at 15 Hz.

(b) State the standard audible range of frequencies for a normal human ear.

(c) Name the technology that utilizes frequencies

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1. The key completes the circuit. When it is open, the bulb does not glow, and the ammeter and voltmeter do not show any reading.
2. When the key is closed, the bulb starts glowing, and the ammeter and voltmeter show some reading.
3. When the resistance is varied by sliding the jockey of the rheostat, the glow of the bulb changes and so do the readings on the ammeter and voltmeter.

5. INSULATORS AND CONDUCTORS

5.1 Insulators

The substances which do not allow the current to flow through them are called insulators. They do not have free electrons and they offer very high resistance.

5.2 Conductors

The substances which allow the current to flow through them easily are called conductors. They have a large number of free electrons and they offer very less resistance

6. FLOW OF ELECTRONS

When a positively charged conductor is joined by a metal wire to an uncharged conductor, the electrons flow from the uncharged conductor to the positively charged one.

When a negatively charged conductor is joined by a metal wire to an uncharged conductor, the electrons flow from the negatively charged conductor to the uncharged one.

When a positively charged conductor is joined by a metal wire to a negatively charged conductor, the electrons flow from the negatively charged conductor to the positively charged one.

6.1 Direction of Flow of Current : Conventional and Electronic

1. When two containers are filled with water up to different levels, the water flows from a container containing water at a higher level to the other container irrespective of their size and shape. This is due to the difference in hydrostatic pressure in the two containers.

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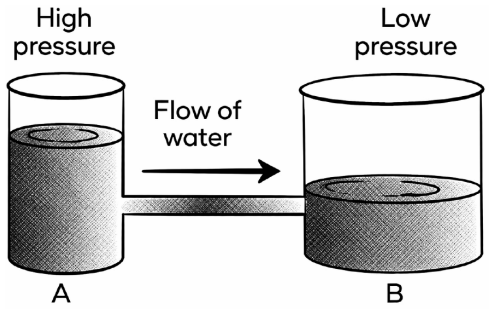
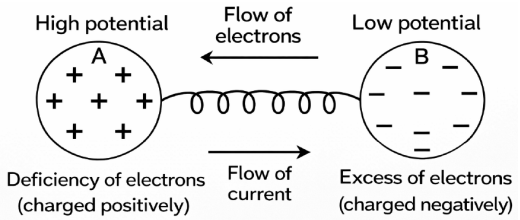


2. When two bodies at different temperatures are kept in contact, the heat flows by conduction from the body at a higher temperature to the body at a lower temperature irrespective of their size and shape.
3. A similar analogy is applied to two charged conductors joined by a metal wire.
4. The conductor with a higher concentration of electrons is said to be at a lower potential, and the conductor with a lower concentration of electrons is said to be at a higher potential.



Flow of electrons and flow of current between the two conductors

5. The electric current flows from a body at a higher potential to a body at a lower potential, and this is called conventional current.
6. This direction is opposite to the direction of flow of electrons which is called electronic current.

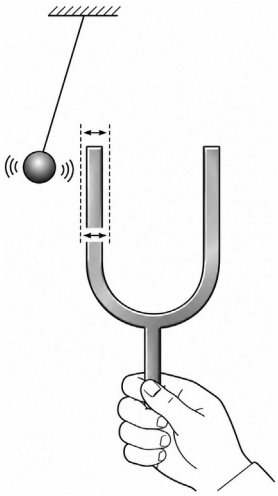
7. POTENTIAL DIFFERENCE

Potential difference between two conductors is equal to the work done in transferring a unit positive charge from one conductor to the other through the metallic wire.

$$\text{Potential difference} = \frac{Work\ done}{Charge} = \frac{W}{q}$$

It is a scalar quantity. Its SI unit is volt (V). The potential difference between two points is said to be 1 volt if the work done in transferring 1 coulomb of charge from one point to the other is 1 joule.

securely mounts a rectangular metallic rod bent into a U-shape onto a rubber pad. He strikes one arm of the metallic device and carefully brings it very close to a small, lightweight sphere suspended by a thin string from a fixed rigid support above.



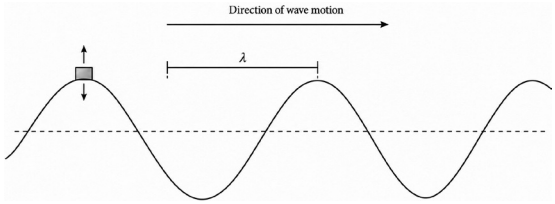
(a) Describe the observation when the left arm of the device is brought close to the suspended sphere, and state the conclusion drawn from this specific observation.
(b) Name the specific type of energy that creates these vibrations in the device and describe what is transferred to the nearby air molecules.

Ans :

(a) 1. As the left arm of the vibrating device is cautiously brought close to the suspended sphere, the ball immediately starts jumping to and fro repeatedly.
2. This physical interaction conclusively proves that sound is produced when a body vibrates, demonstrating that a vibrating body inherently acts as a fundamental source of sound.

(b) 1. It is the applied mechanical energy that effectively creates continuous vibrations within the solid body of the metallic device and subsequently produces the acoustic sound energy.
2. These vibrations of the body are transmitted to the surrounding molecules of the medium in the form of waves without the actual movement of the particles.

119. Tarun observes concentric ripples forming on the quiet surface of a pond after dropping a stone into it. He notices a small piece of light material floating nearby. He watches the floating piece carefully to understand how the disturbance travels outward while the water itself does not flow away. The distance between two consecutive highest points on the water surface is carefully recorded.



(a) State the name of the highest points and the lowest points formed by the disturbance on the water surface.
(b) Identify the specific type of wave propagating on the surface of the pond water based on the diagram.
(c) Describe the motion of the rectangular block as the disturbance moves outward towards the right side.
(d) Name the physical quantity that corresponds to the distance between the highest point of the first peak and the highest point of the second adjacent peak as marked in the diagram.

Ans :

(a) The raised rounded peaks formed by the disturbance are called crests, whereas the lowered rounded dips on the water surface are strictly identified as troughs.
(b) Based on the alternating crests and troughs displayed in the diagram, the specific type of wave propagating on the pond surface is a transverse wave.
(c) The floating rectangular block merely tosses up and down about its mean position without experiencing any forward or backward displacement as the disturbance moves outward.
(d) The specific physical quantity that corresponds precisely to the linear distance spanning between two consecutive highest peaks marked in the provided diagram is the wavelength.

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(A) 4.5 volts
(B) 6.0 volts
(C) 10.5 volts
(D) 13.5 volts

Ans : (B)

Electric potential difference is mathematically heavily defined as the total mechanical work successfully completed per unit of moving charge. By carefully dividing exactly nine joules of performed work by precisely one point five coulombs of charge, we accurately determine six volts.

5. How much total electric charge successfully flows completely through a designated cross-section if a continuous current of exactly 1.5 amperes strictly passes for precisely 2.0 seconds?
(A) 0.75 coulombs
(B) 3.0 coulombs
(C) 4.5 coulombs
(D) 3.5 coulombs

Ans : (B)

The absolute total electric charge successfully transferring through any continuous metallic conductor can be reliably mathematically determined. By accurately multiplying the uniform steady electric current of precisely one point five amperes by exactly two seconds interval, strictly three total coulombs yield.

6. Which of the following examples perfectly represents an irreversible primary cell?
(A) Lead-acid accumulator
(B) Nickel-cadmium cell
(C) Lithium-ion accumulator
(D) Leclanche cell

Ans : (D)

Primary cells are specifically designed for single use because their internal chemical reactions are strictly irreversible. A Leclanche cell represents a standard primary cell, whereas lead-acid and lithium-ion accumulators are officially classified as secondary cells due to their distinct recharging capabilities.

7. A reliable external battery firmly applying exactly twelve volts is properly connected strictly across a wire possessing exactly twenty-four ohms. What is the precise resulting current?
(A) 0.5 amperes
(B) 2.0 amperes
(C) 36.0 amperes
(D) 288.0 amperes

Ans : (A)

According strictly to Ohm's fundamental electrical relationship, the steady current continuously flowing through a complete circuit equals total applied voltage divided directly by overall circuit resistance. Applying twelve total volts securely across twenty-four total ohms perfectly yields exactly zero point five amperes.

8. What specific material is generally utilized to manufacture the heavily coiled wire found inside a standard laboratory rheostat?
(A) Pure highly conductive copper
(B) Oxidized manganin alloy
(C) Standard insulated rubber
(D) Pure industrial grade aluminum

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Ans : (B)

A rheostat functions as an adjustable variable resistor utilized to securely control circuit current smoothly without physical disruptions. It typically consists of durable oxidized manganin wire heavily wound over an insulating asbestos pipe, featuring a movable sliding contact for adjustments.

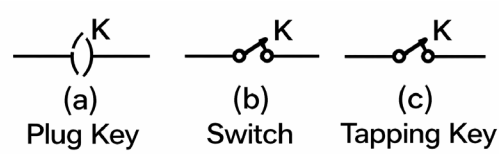
9. Carefully analyze the following statements regarding the fundamental properties of electric current:
I. Electric current is strictly considered a scalar quantity.
II. The standard scientific unit of current is coulomb per second.
III. One ampere equals the continuous flow of 6.25×10^{18} electrons per second.
IV. Conventional current physically flows from lower potential to higher potential.
Identify the correct combination of statements:
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

Ans : (A)

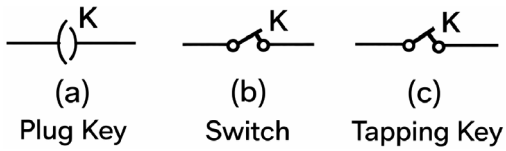
Electric current is fundamentally a scalar quantity measured formally in amperes, which perfectly equates to one coulomb per second. Conventional current flow is strictly considered to move continuously from a region of higher electrical potential toward a region of lower potential.

10. Which fundamental characteristic correctly distinguishes alternating current from direct current?
(A) Alternating current consistently flows in one single uniform direction.
(B) Alternating current maintains an absolutely

1. Key: It is used to put the current on and off in a circuit.
When a key is open, the circuit is called an open circuit.

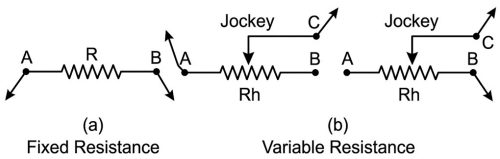


When key is closed

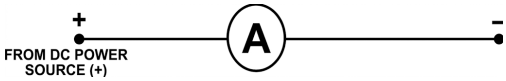


Symbolic representation of different keys
When a key is closed, i.e., the plug is inserted, the circuit is called a closed circuit.
The symbol of the key is K.

2. Resistance wire, resistance box, rheostat or variable resistance: A resistance wire is made up of an alloy of nichrome and has a fixed resistance value depending on its length and thickness.
A resistance box is provided with several standard resistances connected in series.
A rheostat is a continuous varying resistance device used to adjust the magnitude of current in a circuit.
Fixed resistance is represented by the symbol R, and the rheostat or variable resistance is given by the symbol Rh.

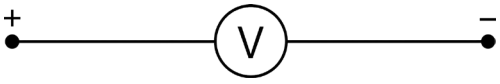


3. Ammeter: An ammeter is used to measure the magnitude of current flowing in a circuit. It is to be connected in series. It is represented by the symbol A enclosed in a circle.



An ammeter should have a low resistance so that the resistance in a circuit does not alter much.

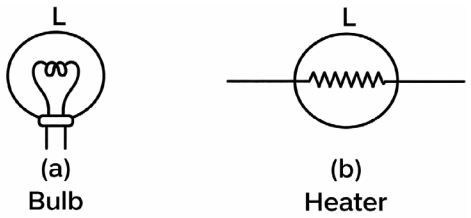
4. Voltmeter: A voltmeter is used to measure the magnitude of potential difference between two points in a circuit. It is to be connected across two points, i.e. in parallel to the flow of current. It is represented by the symbol V enclosed in a circle



A voltmeter should have a high resistance so that it does not draw much current from the circuit.

5. Galvanometer. A galvanometer is used in a circuit when a small current is to be measured or to know the direction of flow of current. It is also connected in series in the circuit. It is represented by the symbol G enclosed in a circle.

6. Load: An appliance connected in a circuit is called load. It is represented by the symbol L.

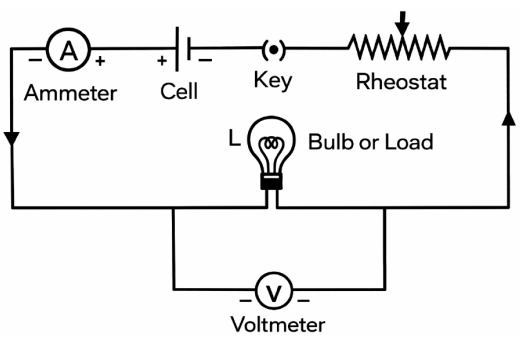


Symbolic representation of a load

7. Connecting wires: The wires used to connect different electrical components are called connecting wires. They are made of highly conducting metal such as copper or aluminium.

4. ELECTRIC CIRCUIT

A simple circuit comprises components such as a cell, key, bulb, ammeter, voltmeter and rheostat.



Functions of Various Components in a Circuit

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A is cross-sectional area. For wire X, $l_x = 2l_\gamma$ and $A_x = A_\gamma/2$. Therefore, $R_x = \rho(2l_\gamma / (A_\gamma/2)) = 4 \times \rho(l_\gamma/A_\gamma) = 4\ R_\gamma$. The resistance of wire X is four times the resistance of wire Y.

15. What inevitably happens when an electric circuit is formally classified as an open circuit?
(A) All connected components instantly draw heavily maximized electrical current.
(B) The conducting path is practically broken and no continuous current flows.
(C) The primary switch automatically bypasses the connected electrical load.
(D) The internal resistance of the utilized connecting wires drops to exactly zero.

Ans : (B)

An open electric circuit fundamentally contains a broken conducting physical path or disconnected switch, completely halting the flow of electricity. Consequently, any connected load such as a light bulb fails to glow since electrons cannot traverse the incomplete continuous loop.

16. Carefully analyze the following statements regarding the proper usage of an ammeter:
I. It is primarily utilized to measure the precise magnitude of electric current.
II. It must consistently be connected in parallel across the electrical load.
III. It intentionally possesses an exceptionally low internal electrical resistance.
IV. It is universally denoted by the capital letter V enclosed in a circle.
Identify the correct combination of statements:
(A) I and III
(B) I and II
(C) II and IV
(D) III and IV

Ans : (A)

An ammeter is a highly specialized measuring instrument explicitly designed to evaluate current magnitude. It must always be connected strictly in series with the functioning circuit and possesses exceptionally low resistance to avoid altering the actual flowing current being accurately measured.

17. What primary operational function does a standard sensitive galvanometer strictly serve within an electrical circuit?
(A) It deliberately increases the total equivalent resistance of the entire circuit.
(B) It accurately detects the precise presence and exact direction of very weak current.
(C) It smoothly adjusts the continuous magnitude of the flowing electrical voltage.
(D) It constantly provides a highly stable source of reliable alternating current.

Ans : (B)

A galvanometer is a highly sensitive scientific detection instrument thoroughly capable of identifying the mere presence and exact direction of extremely weak electrical currents. Unlike a standard calibrated ammeter, it does not typically provide a direct numerical magnitude of flowing current.

18. The table describes the movement of dominant charge carriers in different media. In which scenario does the direction of carrier flow represent the direction of conventional current?

Scenario	**Medium**	**Dominant Charge Carrier**	**Direction of Flow**
1	Copper Wire	Electrons	From A to B
2	Electrolytic Solution	Positive Ions (Cations)	From C to D
3	Electrolytic Solution	Negative Ions (Anions)	From E to F
4	Gas Discharge Tube	Electrons	From G to H

(A) Scenario 1
(B) Scenario 2
(C) Scenario 3
(D) Scenario 4

Ans : (B)

Conventional current is defined as the direction of flow of positive charge. In Scenario 2, the charge carriers are positive ions (cations), so their direction of flow from C to D is, by definition, the direction of conventional current. In metals and gases, electron flow is opposite to the conventional current direction.

19. Read the given assertion and reason carefully, then choose the correct option strictly from the choices below.
Assertion (A) : Completely pure unadulterated water strongly resists allowing electric current to pass through it effectively.
Reason (R) : Completely pure water severely lacks a sufficient number of available free electrons

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S. Standard Galvanometer

List-II

I. Effectively controls current securely by offering a smoothly varying internal resistance
II. Highly sensitive device used exclusively to detect extremely weak continuous current
III. Strictly used to actively measure the exact potential difference across designated points
IV. Always connected strictly in series to measure exact flowing current magnitude

(A) P-IV, Q-III, R-I, S-II
(B) P-III, Q-IV, R-II, S-I
(C) P-I, Q-II, R-III, S-IV
(D) P-IV, Q-I, R-III, S-II

Ans : (A)

The properly installed ammeter accurately records precise current flow, whereas the specialized parallel voltmeter correctly identifies exact potential differences. Furthermore, the variable rheostat physically controls circuit current by altering resistance, and the sensitive galvanometer efficiently detects extremely minute electrical currents.

29. What internal microscopic physical event primarily creates a heavily noticeable stumbling block strictly offering significant electrical resistance?

(A) The spontaneous continuous division of massive stable atomic nuclei
(B) The frequent energetic collisions between moving free electrons and stationary positive metal ions
(C) The total complete structural absence of any freely moving electrical charge carriers
(D) The continuous complete conversion of heavy metallic mass directly into pure electromagnetic radiation

Ans : (B)

Electrical resistance physically originates strictly from frequent microscopic collisions occurring between continuously moving free electrons and stationary positive metal ions. These violent internal physical interactions force traveling electrons to rapidly lose accumulated kinetic energy, subsequently converting it into sensible thermal heat.

30. According to Ohm's fundamental law, what specific physical condition must remain absolutely continuously constant for the relationship to remain valid?

(A) The total internal mass of the complete circuit setup
(B) The physical temperature of the metallic conducting wire
(C) The total operating volume of the connected electrochemical cell
(D) The physical applied magnetic field strictly surrounding the environment

Ans : (B)

Ohm's fundamental scientific law clearly establishes that the continuous electrical current traveling through a metallic conductor remains strictly directly proportional to applied potential difference. However, this mathematically strict relationship requires the physical temperature of the metallic wire to remain absolutely constant.

31. The table below lists different materials and their specific resistance (resistivity) at room temperature. Which material is most suitable for making the heating element of a toaster?

Material	**Specific Resistance (r) at 20°C (W·m)**
Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Manganin	4.82×10^{-8}
Nichrome	1.10×10^{-8}

(A) Silver
(B) Copper
(C) Manganin
(D) Nichrome

Ans : (D)

A heating element requires a material with high resistivity to produce significant heat (Joule heating) and a high melting point. Nichrome has the highest specific resistance among the options, making it ideal for converting electrical energy into heat efficiently. Silver and copper are excellent conductors used for wires, not heaters.

32. Read the given assertion and reason carefully, then choose the correct option strictly from the choices below.

Assertion (A) : A remarkably thick metallic wire clearly offers much less internal electrical resistance compared to a substantially thin wire of perfectly identical length.

Reason (R) : The total internal electrical resistance of any solid conducting wire is strictly directly proportional to its specific physical area of cross-section.

(A) Both A and R are true and R is the correct explanation of A

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24. The physical concept of electric potential difference is most accurately scientifically compared to which physical occurrence?
(A) The continuous smooth flow of varying heat energy entirely across heavily identical temperatures
(B) The continuous movement of static physical mass strictly within a completely frictionless vacuum
(C) The continuous natural flow of heavy water strictly caused by a distinct difference in hydrostatic pressure
(D) The continuous spontaneous creation of intense magnetic fields strictly inside a completely empty spatial void

Ans : (C)

Just as heavy water naturally flows strictly from a considerably higher hydrostatic pressure level toward a lower pressure level, electrical charge operates similarly. This physical difference in electrical condition heavily dictates the precise continuous direction in which current reliably moves.

25. Which mathematical expression accurately correctly represents the continuous electrical potential difference strictly between two points?
(A) Total Work Done multiplied directly by Total Transferred Charge
(B) Total Transferred Charge divided directly by Total Work Done
(C) Total Work Done divided directly by Total Transferred Charge
(D) Total Moving Current divided directly by Total Internal Resistance

Ans : (C)

The physical concept of potential difference mathematically represents the total mechanical work accomplished while moving a localized unit positive test charge. By formally dividing the total energetic work done by the precise magnitude of the transported charge, scientists reliably determine voltage.

26. How is the precise value of exactly one electrical volt accurately scientifically defined?
(A) When exactly one steady ampere flows continuously for precisely one total second
(B) When precisely one joule of mechanical work strictly moves exactly one coulomb of charge
(C) When exactly one single electron rapidly traverses precisely one meter of metallic wire
(D) When precisely one continuous coulomb of steady charge completely neutralizes one positive stationary ion

Ans : (B)

The standard electrical potential difference perfectly equals precisely one volt when exactly one single joule of physical work is successfully performed. This crucial energy expenditure strictly facilitates the uniform continuous movement of exactly one coulomb of charge across two designated points.

27. The table compares a Primary Cell with an unknown 'Cell Type X'. Based on the characteristics provided, identify a correct example for Cell Type X.

	Primary Cell	**Cell Type X**
Reversibility	The electrochemical reaction is irreversible.	The electrochemical reaction is reversible.
Energy Conversion	When in use, chemical energy is converted to electrical energy.	During charging, electrical energy is converted to chemical; during discharging, chemical is converted to electrical.
Current Draw	It can be used to draw a weak current.	It can be used to draw a heavy current.

(A) Voltaic cell
(B) Leclanche cell
(C) Lead-acid accumulator
(D) Dry cell

Ans : (C)

The characteristics of Cell Type X, such as having a reversible reaction, being able to be charged, and providing a heavy current, are all features of a secondary cell. A lead-acid accumulator is a type of secondary cell. Voltaic, Leclanche, and dry cells are all examples of non-rechargeable primary cells.

28. Match the essential electrical circuit components strictly listed in List-I with their accurate functional descriptions provided in List-II.
List-I
P. Standard Ammeter
Q. Standard Voltmeter
R. Standard Rheostat

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Ans :

According to Ohm's law,

$$I = \frac{V}{R}$$

If V is kept the same and R is doubled then

$$I' = \frac{V}{2R} = \frac{1}{2}$$

$$\frac{V}{R} = \frac{1}{2}I$$

Current flowing in the conductor will be halved.

75. Which material is used to make wires for a resistance box ? Why is this particular material used ?

Ans :

One common material used for wires in resistance boxes is manganin. It is composed of 84 % copper, 12% manganese and 4% nickel. Manganin has a high resistance to corrosion and is also mechanically strong, making it a durable choice for use in resistance boxes. The alloy has the property that its resistance does not vary much with temperature. These properties make manganin an ideal material for precision resistors and resistance wires.

76. Explain why does a metal wire when connected to a cell offer resistance to the flow of current.

Ans :

The flow of current in a metal wire is due to the drift of electrons through it. The metal wire has free electrons. When the ends of metal wire are connected to a cell, the electrons inside it start moving from the negative terminal to the positive terminal. During their movement they collide with the fixed positive ions due to which they loose their speed. But after the collision, they are again accelerated towards the positive terminal. This continues, as a result the electrons do not move in bulk with an increasing speed, but they drift towards the positive terminal. Thus, the metal wire offers some resistance to the flow of electrons (or current) through it.

77. For what purpose is a battery connected in a circuit?

Ans :

A battery is commonly used in electrical circuits to provide a source of DC (direct current) electrical energy to power electrical devices or systems. A battery is a portable source of electrical energy that is made up of one or more electrochemical cells, each of which consists of two electrodes (a positive and a negative electrode) and an electrolyte.

When a battery is connected in a circuit, it supplies electrical energy to the circuit, which can be used to power various devices, such as lights, motors, and electronic devices. The electrical energy from the battery flows through the circuit and is used to perform work or to create an effect, such as producing light, motion, or sound.

78. Give an example to explain that the use of modern eco-friendly technologies is more efficient and less polluting.

Ans :

The examples that explain the use of modern eco-friendly technologies is more efficient and less polluting are as follows:

(a) The modern energy efficient appliances such as refrigerators, freezers, ovens, stoves, dishwashers, dryers, etc. make use significantly less energy than the older appliances. Nowadays appliances are star rated according to their efficient use of electricity.

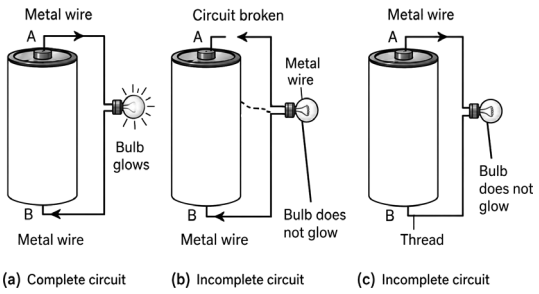
(b) Even, the use of advanced boilers and furnances in industry can save sufficient amount of energy in attaining the high temperature by burning less fuel.

(c) The fuel efficiency vehicles can be increased by reducing the weight of the vehicle, by using advanced tyres and the computer controlled engine systems.

79. Distinguish between a closed circuit and an open circuit, with the use of suitable labelled diagrams.

Ans :

When the key in a circuit is closed (i.e. when the plug is put in) the current flows through the circuit and the circuit is said to be closed. On the other hand, when the key is open (i.e. when the plug is taken out), the circuit is incomplete and no current flows through it. Such a circuit is called an open circuit.



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(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

A significantly thicker conducting wire naturally presents a considerably larger cross-sectional area for traveling free electrons to effectively navigate. Consequently, because total internal resistance remains strictly inversely proportional to this available cross-sectional area, thicker metallic wires successfully provide far less resistance.

33. What inevitably occurs to the total internal electrical resistance of a solid metallic wire when its physical temperature is substantially increased?
(A) The total resistance decreases because stationary positive ions completely stop vibrating.
(B) The total resistance strictly remains unchanged regardless of severe temperature fluctuations.
(C) The total resistance heavily increases because stationary internal ions begin vibrating much more violently.
(D) The total resistance instantly drops to absolute zero creating a perfect superconductor.

Ans : (C)

When the physical temperature of any metallic conductor noticeably increases, its constituent positive ions begin vibrating much more violently. This aggressive rapid molecular motion drastically increases overall internal collision frequency for traveling free electrons, effectively resulting in a substantially higher resistance.

34. How exactly does the total physical length of a standard solid metallic conductor directly affect its overall internal electrical resistance?
(A) Resistance demonstrates a strictly inversely proportional relationship entirely with wire length.
(B) Resistance demonstrates a strictly directly proportional mathematical relationship with wire length.
(C) Resistance heavily remains completely completely independent of any physical length modifications.
(D) Resistance severely drops directly exponentially as the physical wire length vastly increases.

Ans : (B)

The total internal electrical resistance provided consistently by a solid metallic conductor demonstrates a strictly direct proportional relationship with its physical length. Therefore, free electrons traveling across remarkably longer wires will inevitably experience considerably more energy-depleting collisions, noticeably increasing overall resistance.

35. The table shows observations from four attempts to build a simple circuit with a cell, a switch, and a bulb. Which setup correctly corresponds to a functional closed circuit?

Setup	Switch Position	Bulb Status
1	Open	Glows
2	Closed	Does not glow
3	Open	Does not glow
4	Closed	Glows

(A) Setup 1
(B) Setup 2
(C) Setup 3
(D) Setup 4

Ans : (D)

A closed circuit provides a complete, unbroken path for current to flow from the source, through the components, and back. When the switch is closed and the circuit is functional, current flows and the bulb glows. Setup 4 shows this correct condition. Setup 3 shows a correct open circuit, while 1 is impossible and 2 indicates a fault.

36. Carefully analyze the following statements strictly concerning the efficient everyday practical use of modern energy resources:
I. Modern energy-efficient household appliances successfully utilize significantly less total operational energy.
II. CFL and standard LED devices are officially considered highly eco-friendly lighting technologies.
III. Proper thick structural insulation heavily actively increases total heating energy costs during winter.
IV. Advanced industrial boilers reliably increase overall fuel efficiency and strongly reduce environmental pollution.
Identify the correct combination of statements:
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (B)

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Employing advanced eco-friendly domestic technologies like energy-efficient LED lighting actively minimizes unnecessary massive electrical power consumption. Furthermore, properly successfully installing adequate structural thermal insulation significantly prevents unwanted interior heat loss, thereby substantially reliably reducing massive winter heating expenses and protecting environments.

37. Which proactive straightforward social initiative profoundly aids fundamentally in broad global energy conservation efforts?
(A) Intentionally leaving bright task lighting continually active strictly in completely unoccupied empty rooms
(B) Carefully frequently opening heavy modern refrigerator doors entirely during intensely hot summer days
(C) Reliably consistently switching off powerful rotating fans and bright lights immediately when completely unneeded
(D) Exclusively constantly purchasing heavily outdated electrical domestic appliances lacking official energy star ratings

Ans : (C)

Practicing strict daily energy conservation fundamentally heavily involves strategically taking proactive responsible measures to consistently minimize daily energy consumption. Simple routine social initiatives, strictly including intentionally thoroughly switching off unused electrical lighting, significantly help preserve rapidly depleting natural environmental fuel resources.

38. Read the given assertion and reason carefully, then choose the correct option strictly from the choices below.
Assertion (A) : An operational electric cell continuously reliably maintains the vital steady flow of free electrons strictly throughout a completely closed external circuit.
Reason (R) : Irreversible or reversible internal chemical reactions continuously strongly maintain a significant massive excess of free electrons exactly at the cell's negative cathode.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

An operational electric cell practically utilizes internal chemical reactions to successfully continuously generate a lasting electrical potential difference. By consistently maintaining extra loosely bound electrons at the negative cathode, it forcefully effectively pushes moving electrons outward rapidly through the completed circuit.

39. Carefully analyze the following statements thoroughly strictly concerning standard commercial electrochemical cells:
I. Standard primary cells are fundamentally generally completely non-rechargeable due to entirely irreversible internal reactions.
II. Standard secondary cells are often professionally officially referred to as electrical storage accumulators.
III. A standard commercial dry cell is universally considered a prime example of a secondary cell.
IV. Secondary storage cells can successfully reliably draw heavily large electrical currents repeatedly without breaking.
Identify the correct combination of statements:
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (B)

Standard primary cells fundamentally securely rely strictly upon entirely irreversible internal chemical reactions, rendering them entirely virtually incapable of being properly recharged. Conversely, secondary storage energy accumulators heavily feature entirely reversible internal chemistry, securely allowing them to reliably provide massive currents.

ONE MARK QUESTIONS

40. What transformation of energy takes place when current is drawn from a cell ?

Ans :

Chemical energy is converted into electrical energy.

41. Name the instrument used to control the current in an electric circuit.

Ans :

Rheostat

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42. Name one d.c. source and one a.c. source.

Ans :

One d.c. source is a cell and one a.c. source is an a.c. generator.

43. What is an electric cell ?

Ans :

An electric cell is a device that converts chemical energy into electrical energy.

44. How much is the charge on an electron ?

Ans :

Charge on an electron is negative 1.6×10^{-19} coulomb.

45. State and define the S.I. unit of resistance.

Ans :

S.I. unit of resistance is volt per ampere which is named as ohm (symbol Ω).

46. State the two kinds of cell. Give one example of each.

Ans :

Cells are of two kinds :
(1) Primary cells Example - voltaic cell.
(2) Secondary cells Example - lead accumulator.

47. What is the function of a key (or switch) in an electric circuit?

Ans :

The function of key is to put the current on and off in the circuit.

48. Select conductors of electricity from the following: Copper wire, silk thread, pure water, acidulated water, human body, glass, mercury.

Ans :

Conductors of electricity are copper wire, acidulated water, human body and mercury.

49. State the first traditional electric device to be used for home lighting.

Ans :

The first traditional electric device used for home lighting was the incandescent electric bulb (electric lamp).

50. Write the condition required for a circuit to be a closed circuit?

Ans :

The condition required for a circuit to be a closed circuit is that the key should be closed so that an electric current flows through the circuit.

51. 'The potential difference between two conductors is 1 volt'. Explain the meaning of this statement.

Ans :

This means to move a charge of 1 coulomb from one point to other. 1 joule of work will have to be done.

52. 'The resistence of a wire is 1 ohm'. Explain the meaning of this statement.

Ans :

The resistance of a wire is 1 ohm means that a current of 1 ampere will flow through it when a potential difference of 1 volt is applied across its ends.

53. What is a secondary cell ? Name one such cell.

Ans :

These cells provide current as a result of chemical reaction and they can be recharged after use. Examples. Ni - Fe or alkali accumulator.

54. State two ways to save energy.

Ans :

Two ways to save energy are :
(i) Solar energy should be harvested.
(ii) The use of hydro-electric energy, wind energy etc. should be given priority.

55. How does the proper insulation of home save energy?

Ans :

By properly insulating a home, it is possible to maintain a comfortable temperature inside. It will reduce the cost of heating devices in winter and cooling devices in summer. Thus it saves energy.

TWO MARKS QUESTIONS

56. What is a primary cell ? Name two such cells.

Ans :

Primary cell. A cell in which chemical energy is directly converted into electrical energy. They

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required for continuous electrical conduction.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Functional conductors strictly require a massive abundance of loosely bound free electrons to successfully transport electric charge. Pure water acts as a strong insulator because it virtually lacks these essential free electrons, effectively preventing any significant internal electrical charge movement.

20. Why are continuous metallic connecting wires predominantly manufactured using highly conductive metals like pure copper?
(A) Because they possess extremely high internal electrical resistance
(B) Because they present practically negligible electrical resistance to flowing current
(C) Because they actively generate a massive amount of internal thermal energy
(D) Because they heavily restrict the continuous natural movement of free electrons

Ans : (B)

Metallic connecting wires are predominantly manufactured using highly conductive materials like copper or aluminum. These specific standard materials present practically negligible electrical resistance, ensuring that electrical energy travels swiftly and efficiently across the closed circuit without causing unnecessary internal power loss.

21. In an electrical scenario involving two charged conductors connected by a wire, when does the continuous flow of electrons finally cease?
(A) When both conductors successfully attain a perfectly equal concentration of electrons
(B) When the positively charged conductor completely loses all its internal positive ions
(C) When the negatively charged conductor effectively doubles its initial internal mass
(D) When the connecting metallic wire rapidly melts due to excessive internal heating

Ans : (A)

When a highly conductive metal wire effectively joins two oppositely charged objects, electrons instantly begin transferring. This continuous movement of free electrons firmly persists until both connected conductors finally attain an absolutely equal concentration of electrons, entirely neutralizing potential difference.

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22. To verify Ohm's Law, a student takes multiple readings of voltage across a resistor and the corresponding current flowing through it. Based on the data, what is the resistance of the component?

Reading	Potential Difference (V)	Current (I) (A)
1	2.0	0.50
2	4.0	1.00
3	6.0	1.50
4	8.0	2.00

(A) 0.25 Ω
(B) 2.0 Ω
(C) 4.0 Ω
(D) 16.0 Ω

Ans : (C)

According to Ohm's Law, resistance R = V/I. For each reading, the ratio is constant: R_1=2.0/0.5=4.0 Ω; R_2=4.0/1.0=4.0 Ω; R_3=6.0/1.5=4.0 Ω; R_4=8.0/2.0=4.0 Ω. The data consistently shows that the resistance of the component is 4.0 Ω, demonstrating a conductor that obeys Ohm's Law under these conditions.

23. Carefully analyze the following statements regarding electric potential and current flow:
I. Electric potential is fundamentally classified as a strict scalar quantity.
II. The standard scientific SI unit of electric potential is the volt.
III. Free electrons naturally continuously drift from high potential to low potential.
IV. Positive charge theoretically moves steadily from high potential to low potential.
Identify the correct combination of statements:
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (B)

Electric potential perfectly acts as a simple scalar quantity measured practically in volts. While free electrons naturally drift strictly from regions of lower potential to higher potential, conventional positive charges theoretically move exactly from higher potential points toward lower potential regions.

67. How are the potential difference (V), current (I) and resistance (R) related ?

Ans :

Relation is

$$\text{Potential difference} = \text{Resistance} \times \text{Current}$$

$$V = IR$$

or $$R = \frac{V}{I}$$

or $$I = \frac{V}{R}$$

68. What are conductors and insulators of electricity? Give two examples of each.

Ans :

The substances which allow the current to flow through them easily, are called conductors. They offer very small resistance in the path of current.
Two examples : Copper, Silver
Insulators : The substances which do not allow the current to flow through them, are called Insulators. They offer very high resistance in the path of current.
Two examples : Rubber, Glass

69. What is indicated by the different number of stars on an electric appliance?

Ans :

The different number of stars on an electric appliance usually indicates the energy efficiency of the appliance the more energy - efficient it is considered to be.
In many countries, a star rating system is used to indicate the energy efficiency of appliances such as refrigerators, air conditioners, washing machines, and televisions. The system is typically based on a scale of 1 to 5 stars, with 5 stars being the most energy-efficient rating.

70. What is the other name for the unit :
(a) Joule per Coulomb
(b) Coulomb per second?

Ans :

The unit joule per second is also known as a watt, which is the standard unit of power in the International System of Units (SI). The watt is commonly used to measure the rate of energy transfer or the rate at which work is done.
The unit coulomb per second is also known as an ampere, which is the standard unit of electric current in the SI system. The ampere is used to measure the rate of flow of electric charge.

71. n electrons flow through a cross - section of a conductor in time t. If charge on an electron is e, write an expression for the current in the conductor.

Ans :

Charge on one electron $= e$
Charge on n electrons $Q = ne$

$$\text{Time} = t \text{ seconds}$$

$$\text{Current} = \text{Rate of flow of charge}$$

$$I = \frac{Q}{t}$$

$$= \frac{ne}{t}$$

$$I = \frac{ne}{t}$$

THREE MARKS QUESTIONS

72. What do you understand by the term resistance ?

Ans :

Resistance The flow of current in a wire is due to the drift of electrons. The electrons frequently collide with the atoms of the wire as they move through it. The rate of flow of charge decreases. Thus, when current flows through a conductor, it offers obstruction to the flow of current.
Resistance. The friction or obstruction offered to the passage of electric current by a material is called resistance.

73. State three factors on which the resistance of a wire depends. Explain how does the resistance depend on the factors stated by you.

Ans :

Factors on which the resistance of a wire depends are :
(i) Length of the wire. $R \propto I$
i.e. longer the wire, more is the resistance.
(ii) The area of cross - section of the wire. $R \propto \frac{1}{a}$
i.e. a thin wire offers more resistance.
(iii) Temperature. The resistance of wire increases with increase in temperature.

74. How is the current flowing in a conductor changed if the resistance of conductor is doubled keeping the potential difference across it the same?

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cannot be recharged.
Examples.
(1) Simple voltaic cell (2) Leclanche cell.

57. Which of the following device is most efficient for the lighting purpose :
LED, CFL, Fluorescent tube light, Electric bulb.

Ans :

LED is the most efficient for the lighting purpose. The use of LED bulbs for lighting reduces the consumption of energy drastically. It is also helpful in reducing the global warming and the harmful effects of mercury used in the fluorescent light.

58. What do you understand by the term current ? State and define its S.I. unit.

Ans :

The rate of flow of charge (electrons) per second is called current.
S.I. unit of current is Ampere (A).
The current is $1\,A$, if the rate of flow of charge is 1 coulomb per second.

59. State two differences between a conductor and an insulator of electricity.

Ans :

(i) Conductor do not have free electrons whereas insulator have a large number of free electrons
(ii) Conductors offer a very high resistance in the path of current whereas insulator offer a very small resistance in the path of the current.

60. State and define the S.I. unit of potential difference.

Ans :

S.I. unit of potential difference is Volt.
Volt : The potential difference between two points is said to be 1 volt if the work done in transferring 1 coulomb of charge from one point to the other point is 1 joule.

61. State whether the resistance of filament of a bulb will decrease, remain unchanged or increase when it glows.

Ans :

As the current in the filament of a light bulb increases, thus leads to reduction of the resistance of filament of a bulb, and the bulb glows brighter. The resistance of filament of a bulb will decrease when it glows.

62. State Ohm's law.

Ans :

The current flowing in a conductor is directly proportional to the potential difference across its ends, keeping temperature constant.

i.e., $\quad V \propto I$

$$V = IR$$

(Where R is the resistance of the conductor)

63. Define the term potential difference ?

Ans :

The potential difference between two conductors is equal to the work done in transferring a unit positive charge from one conductor to other conductor through the metallic wire. The potential difference is given by

$$V = \frac{W}{q}$$

64. Name the constituents of a cell.

Ans :

The constituents of a cell are :-
(i) A container or vessel made up of glass, zinc or copper etc.
(ii) Electrodes : These are the two conducting rods dipped in a solution kept in cell.
(iii) The solution in cell called as Electrolyte in which the electrodes are dipped.

65. Name the physical quantities of which the units are :
(a) Coulomb and ampere.
(b) Volt and Ohm.

Ans :

(a) Coulomb is the unit of charge and Ampere is the unit of current.
(b) Volt is the unit of potential difference and Ohm is the unit of resistance.

66. What is meant by the efficient use of energy ?

Ans :

The meaning of efficient use of energy is to reduce the cost and amount of energy to be used to provide us the various products and services. Energy efficiency can be achieved by adopting more efficient ecofriendly technologies and processes. This results in reduction of (i) The cost of energy, (ii) The emission of green house gas.

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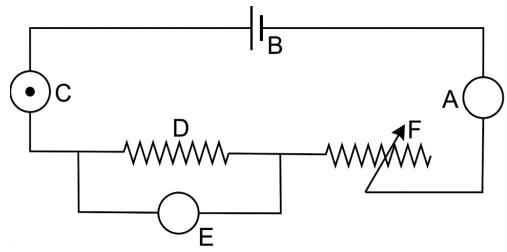
80. State three differences between the primary and secondary cells.

Ans :

The difference between the primary and secondary cells are as follows :

	Primary cell	**Secondary cell**
1.	Chemical reaction is irreversible.	Chemical reaction is reversible.
2.	Only chemical energy is converted into electrical energy when current is drawn from it.	Electrical energy converts into chemical energy in it (i.e., during charging), while chemical energy converts into electrical energy when current is drawn from it (i.e., discharging)
3.	It can not be recharged.	Only chemical energy is

81. In the electric circuit shown in Fig. label the parts A, B, C, D, E and F. State the function of each part. Show in the diagram the direction of flow of current.



Ans :

A – Ammeter

B – Cell

C – Key

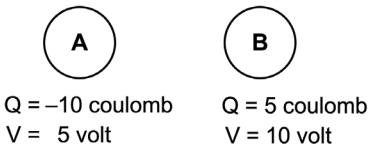
D – Unknown Resistance [Buldb or Load]

E – Voltmeter

F – Rheostat or Variable resistance

Functions are as stated in Q. 4.

82. Fig. below shows two conductors A and B. Their charges and potentials are given in diagram. State the direction of (i) flow of electrons and (ii) flow of current, when both the conductors are joined by a metal wire.



Ans :

(i) Flow of electrons will be from a low potential to a high potential.
As, the potential in conductor A ($V = 5$ volts) is lower than that of conductor B (V =10 volt), the flow of electrons will be from conductor A to conductor B.

(ii) Flow of current will be from a high potential to a low potential.
As, the potential in conductor B ($V = 10$ volt) is higher than that of conductor A ($V = 5$ volt), the flow of current will be from B to A.

83. How is *CFL* better than a usual bulb?

Ans :

CFL (Compact Fluorescent Lamp) bulbs are more energy-efficient than traditional incandescent bulbs, and they also have a longer lifespan. Here are some ways in which *CFL* bulbs are better than traditional bulbs:

1. Energy efficiency: *CFL* bulbs use less energy than incandescent bulbs to produce the same amount of light. This means that *CFL* bulbs can help to reduce electricity bills and save energy.
2. Longer lifespan: *CFL* bulbs last longer than incandescent bulbs, which need to be replaced more frequently. A typical *CFL* bulb can last up to 10 times longer than an incandescent bulb.
3. Less heat generation: *CFL* bulbs generate less heat than incandescent bulbs, which can make them safer to use in certain applications, such as in lamps or other enclosed spaces.

84. What is meant by load in an electrical circuit? Give some examples.

Ans :

In an electrical circuit, a load refers to any component or device that consumes electrical power to perform a desired function. The load can be thought of as the electrical demand placed on the circuit, as it determines the amount of current that flows through the circuit.

1. Incandescent light bulbs : These are passive loads that convert electrical energy into heat and light.

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entities.

(d) State what happens to the kinetic energy of the negatively charged particles when they collide with the fixed positive entities.

Ans :

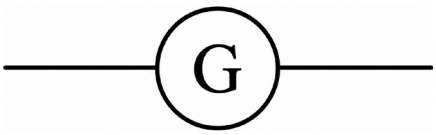
(a) The extremely small circles marked with a minus sign uniquely represent the free electrons actively moving through the metallic conductor.

(b) The notably larger circles perfectly marked with a plus sign structurally represent the rigidly fixed positive ions of the metal wire.

(c) The fundamental phenomenon that severely arises strictly due to these continuous physical collisions is called electrical resistance.

(d) When the rapidly moving electrons suddenly collide with the fixed positive ions, they transfer their kinetic energy and slow down, ultimately causing the resistor to heat up.

112. Tina was constructing a highly sensitive electrical circuit for a science fair project. She needed an instrument that could quickly detect the presence of a very weak current without necessarily providing its exact magnitude. She selected a specific circular component from her kit and placed it into her circuit loop. The diagram below illustrates the exact symbol printed on the dial of the instrument she used.



(a) Identify the electrical instrument represented by the symbol in the diagram.

(b) State the primary purpose of this specific instrument in Tina's electrical circuit.

(c) State how this instrument should be connected in a circuit with respect to the components through which the current is being investigated.

(d) Give one reason why there are no plus or minus signs marked on the terminals of this particular instrument.

Ans :

(a) The sensitive electrical instrument unambiguously represented by the symmetrical circular symbol in the given diagram is a galvanometer.

(b) The fundamental primary purpose of a galvanometer is to perfectly detect the active presence of very weak current or accurately determine the direction of flow of current.

(c) The chosen galvanometer must absolutely always be meticulously joined directly in series with the specific circuit components being actively investigated.

(d) There are completely no plus or minus signs marked essentially because current can freely come in and neatly leave through absolutely any of its available terminals.

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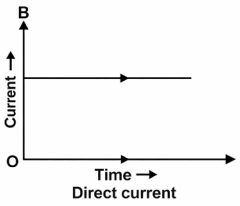
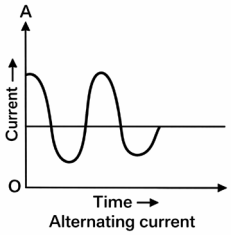
Ans :

The difference between the direct current and alternating current are as follows :

	Direct current	**Alternating current**
1.	It is uniform throughout.	It is not uniform.
2.	Its magnitude always remain the same.	Its magnitude increases uniformly.
3.	Its direction does not change or remains the same.	Its direction changes after a definite interval of time
4.	Its graph is a straight line.	Its graph is not a straight line, but curved.
		

89. Describe three ways for the efficient use of energy.

Ans :

Ways for efficient use of energy : The efficient use of energy means to reduce the amount of energy required to provide us the various products and services. The various methods are:

(i) Use *CFL* (compact fluoroscent lights) and hence to get required lights and to save 67% energy.

(ii) Insulating homes to use less heating and cooling energy to achieve and maintain a comfortable temperature.

(iii) Use modern efficient appliances such as freezers, ovens, stoves, dishwashers and dryers etc. and discard older appliances.

(iv) The use of advanced boilers and furnaces in Industry.

(v) Use light weight vehicles with advanced tyres and computer controlled engines.

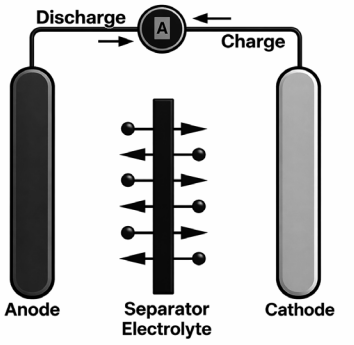
In this way we can reduce the world's energy by one third.

90. How will you obtain a source of large direct current? Show it with the help of a diagram.

Ans :

Secondary cells, also known as rechargeable batteries or accumulators, can also be used as sources of large DC current. These batteries are capable of storing and releasing electrical energy and can be recharged many times over their useful life.

In order to obtain a large source of *DC* current from secondary cells, the cells are usually connected together in series or parallel to increase the voltage and current output. For example, a battery bank made up of multiple lead-acid cells can provide a large source of *DC* power that can be used for various applications, such as backup power for data centres, emergency lighting, or electric vehicles.



91. How does current change with voltage when it is altered across a given resistance ?

Ans :

According to Ohm's Law, the current through a given resistance is directly proportional to the voltage across it, when the resistance is constant. This relationship can be expressed mathematically as:

$$I = \mathrm{V/R}$$

Where I is the current flowing through the resistance, V is the voltage across the resistance, and R is the resistance of the circuit.

It can be seen that when the voltage across a given resistance is increased, the current through the resistance will also increase, provided that the resistance remains constant. Conversely, if the voltage is decreased, the current will also decrease. For example, if we have a 10 ohm resistor connected to a 12-volt battery, the current through the resistor can be calculated as:

$$I = V/R = 12$$

$$V/10 \text{ ohms} = 1.2 \text{ Ampere}$$

If we increase the voltage across the resistor to 24 volts, the current through the resistor will double to:

$$I = V/R = 24$$

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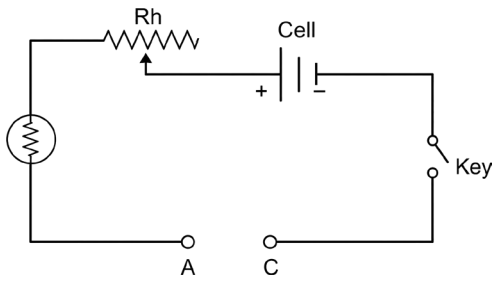
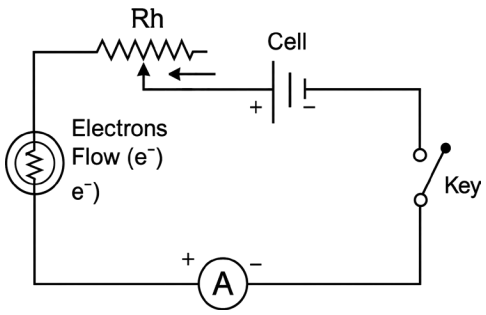
2. Electric motors : These are active loads that convert electrical energy into mechanical motion, and are used in a wide range of applications, from household appliances to industrial machinery.
3. Heating elements : These are passive loads that convert electrical energy into heat, and are commonly used in electric stoves, water heaters, and space heaters.

In general, the load in an electrical circuit determines the amount of current that flows through the circuit, which in turn affects the voltage and power delivered to the load.

85. (a) Complete the circuit given in Fig. by inserting between the terminals A and C, an ammeter.
(b) In the diagram mark the polarity at the terminals of ammeter and indicate clearly the direction of flow of current in the circuit, when the circuit is complete.
(c) Name and state the purpose of Rh in the circuit.



Ans :



Purpose of Rh is to vary the resistance.

FOUR MARKS QUESTIONS

86. Explain the concept of electric potential difference in terms of the work done in transferring the charge.

Ans :

The heat flows from body at high temperature to body at low temperature till the temperature of both the bodies is same.
Much the same way current flows from high potential to low potential.
When two conductors are placed in contact or joined by metallic wire free electrons flow from a conductor having more number of electrons to conductor having less number of free electrons.
The conductor having excess of electrons (more electrons) is said to be at a negative or lower potential while the conductor having deficit of electrons (less of electrons) is said to be at a positive or higher potential.
To move charge from higher potential [Low concentration of electrons] to lower potential [High concentration of electrons]. Some work has to be done.
Thus, potential difference is equal to the work done in moving (transferring) a unit positive charge from one conductor to the other through the metallic wire.

$$V = \frac{W}{q}$$

87. A galvanometer has an 'O' mark at the middle, while a voltmeter and ammeter has the mark at the left hand corner of the dial. Explain.

Ans :

In a galvanometer, the zero mark, often represented by the letter O, is located at the centre of the dial. This is because galvanometers are primarily used to measure small electrical currents, and their needles can deflect in both positive and negative directions from the zero point.

In contrast, voltmeters and ammeters typically have their zero marks located at the left-hand corner of the dial. This is because these instruments are designed to measure electrical quantities that are usually positive in nature, such as voltage or current, and their needles typically deflect only in one direction.

For example, a voltmeter is used to measure the potential difference or voltage between two points in a circuit. When there is no voltage difference between these points, the needle of the voltmeter should point to zero, which is located at the left-hand corner of the dial. Similarly, an ammeter is used to measure the current flowing through a circuit. When there is no current flowing, the needle of the ammeter should point to zero, which is also located at the left-hand corner of the dial.

88. Distinguish between direct current and alternating current.

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NUMERICAL QUESTIONS

94. A bulb draws current 1.5 A at 6.0 V. Find the Resistance of filament of bulb while glowing.

Ans :

Given, $I = 1.5A$

$V = 6.0\,V$

Resistance of filament of bulb

$$= R = \frac{V}{I}$$

$$= \frac{6.0}{1.5} = 4$$

Ohm or 4Ω

95. A current 0.2 A flows in a wire of resistance 15 Ω. Find the potential difference across the ends of the wire.

Ans :

Given, $R = 15\,\Omega$

$I = 0.2\,A$

From Ohm's Law, $V = IR$

Therefore, Potential Difference

$$= 15 \times 0.2$$

$$= 3.0\,V$$

96. A charge 0.5 C passes through a cross section of a conductor in 5 s. Find the current.

Ans :

Charge $Q = 0.5\,\text{C},$

$t = 5\,\text{seconds}$

Current $I = \frac{Q}{t}$

$$= \frac{0.5}{5}$$

$$= 0.1\,\text{A}$$

$I = 0.1\,\text{A}$

97. When starter motor of a car is switched on for 0.8s, a charge 24 C passes through the coil of the motor. Calculate the current in the coil.

Ans :

Here, $t = 0.8\,s$

$Q = 24\,\text{C}$

$$I = \frac{Q}{t}$$

$$= \frac{24}{0.8} = 30\,\text{A}$$

$I = 30\,\text{A}$

98. A current of 1.5 A flows through a conductor for 2.0 s. What amount of charge passes through the conductor?

Ans :

Given, $I = 1.5\,\text{A}$

$t = 2.0s,$

$Q = ?$

$I = \frac{Q}{t}$

$Q = I \times t$

$= 1.5 \times 2$

$= 3\ \text{C}$

99. A cell of potential difference 12 V is connected to a bulb. The resistance of filament of bulb when it glows, is 24 Ω. Find the current drawn from the cell.

Ans :

Here, Potential difference $V = 12\,V$

Resistance $R = 24\,\Omega$

Current $I = ?$

$V = IR$

$I = \frac{V}{R}$

$\frac{12}{24} = 0.5\,A$

100. In transferring 1.5 C charge through a wire, 9 J of work is needed. Find the potential difference across the wire.

Ans :

Here, charge $Q = 1.5\,C$

Work done $W = 9\,J$

Potential difference $V = \frac{W}{Q}$

$V = \frac{9}{1.5}$

$= \frac{90}{15} = 60$ volt

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Neha must do to the switch to make the bulb glow.

Ans :

(a) 1. The specific electric circuit shown in the provided diagram is clearly identified as an open electric circuit or an incomplete circuit.
2. The light bulb is not emitting light because the electric contact is completely broken at the switch, meaning absolutely no current flows through the path.

(b) 1. The component consisting of two vertical parallel lines of entirely unequal length perfectly represents an electric cell, which acts as the source of direct current.
2. Neha must firmly close the switch by pushing the angled line segment completely down to properly establish a continuous conducting path.

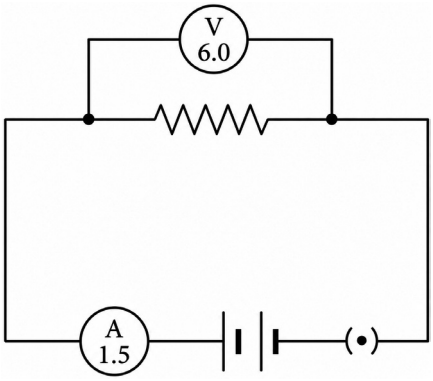
107. Anjali was assembling a basic test circuit on her workbench using a battery, a small light bulb, and several connecting leads. She decided to test various materials by placing them in the gap between two free ends of the circuit. First, she inserted a silver coin and noted her observation. Next, she removed the coin and bridged the gap using a dry wooden stick. Anjali observed a distinct difference in the behaviour of the light bulb in the two cases. Her teacher explained that this was due to the internal atomic structure of the materials.

(a) Name the category of substances to which the silver coin belongs based on its electrical behaviour.
(b) State the specific structural feature inside the silver coin that allows it to behave this way.
(c) Name the category of substances to which the dry wooden stick belongs.
(d) State what happens to the light bulb when the dry wooden stick is placed in the circuit.

Ans :

(a) The solid silver coin belongs strictly to the category of electrical conductors, which are substances that allow electric current to pass through them easily.
(b) The silver coin possesses a very large number of free electrons which effortlessly offer very little resistance to the flow of electric current.
(c) The dry wooden stick belongs directly to the category of electrical insulators, which are substances that do not allow electric current to pass through them.
(d) The connected light bulb simply does not glow because the dry wooden stick has almost no free electrons, leaving the electric circuit totally incomplete.

108. Manish set up an electrical circuit on his laboratory table to investigate the relationship between current and voltage. He connected a constant direct current source to a metallic resistor and switched on the circuit. The measuring instruments provided steady readings as depicted in the diagram below. Manish carefully recorded these numerical values to determine the properties of the metallic resistor.



(a) Identify the measuring instrument denoted by the letter V and the instrument denoted by the letter A.
(b) State the mathematical law that relates the potential difference across the metallic wire to the current flowing through it at a constant temperature.
(c) Calculate the electrical resistance of the metallic resistor using the numerical readings provided in the diagram.

Ans :

(a) The measuring instrument denoted by the letter V is a voltmeter, and the instrument precisely denoted by the letter A is an ammeter.
(b) Ohm's law clearly states that the current flowing through a metallic wire is directly proportional to the potential difference applied across its ends provided its temperature is constant.
(c) $R = V/I = 6.0/1.5 = 4.0$

109. Divya was instructed to vary the magnitude of current in her experimental circuit without changing the voltage source. She picked up a cylindrical electrical device from the laboratory shelf, which is illustrated in the diagram below.

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closed circuit, the chemical energy stored inside the cell is converted into electrical energy.

2. The chemical reaction occurring inside the primary cell of the television remote control is entirely irreversible.

104. Meera was conducting a home energy audit to help her parents reduce their monthly electricity bill and minimize greenhouse gas emissions. She noticed that several rooms were illuminated by traditional incandescent electric bulbs which consumed significant energy. Her mother also left the refrigerator door open frequently while cooking. Meera advised her parents to adopt eco-friendly technologies and implement simple behavioural changes to conserve their resources. She explained that adopting such sustainable development practices is essential to safeguard the environment for future generations.

(a) Suggest two modern, energy-efficient lighting devices that Meera should recommend to replace the incandescent bulbs.

(b) State two social initiatives or habits Meera's family should adopt regarding the refrigerator and natural daylight to conserve energy.

Ans :

(a) 1. Meera should strongly recommend using Compact Fluorescent Lamps (CFLs) to replace the older traditional incandescent electric bulbs.

2. She should also recommend installing Light Emitting Diode (LED) lights in the house as they are highly energy-efficient and eco-friendly lighting devices.

(b) 1. The family must avoid opening the door of the refrigerator frequently and ensure they do not overload the appliance to maintain efficiency.

2. They should take advantage of natural daylight by using light-coloured, loose-weave curtains on windows to allow sunlight to effortlessly penetrate the room.

105. Rohan was given four different metallic wires in his physics laboratory to investigate electrical properties. The first wire was a standard copper wire of one metre length. The second wire was also of copper but two metres long, while the third wire was a much thicker copper wire of one metre length. The fourth wire was made of nichrome instead of copper, but had the exact same dimensions as the first wire. He connected each wire to a battery and gently heated them one by one to observe the changes in their properties.

(a) State what happens to the resistance of the wire when Rohan uses the two-metre copper wire instead of the one-metre copper wire.

(b) Compare the resistance of the thick copper wire with the thin copper wire of the same length.

(c) State what happens to the resistance of the copper wire when Rohan increases its temperature by heating it.

(d) Give one reason why the standard copper wire and the nichrome wire of identical dimensions offer different resistances.

Ans :

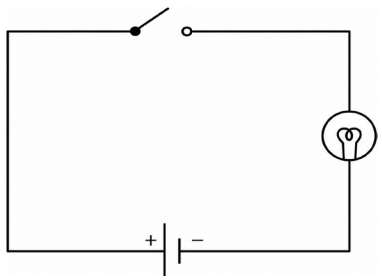
(a) The electrical resistance of the wire increases significantly because the resistance of any conductor is directly proportional to its total length.

(b) The thick copper wire will offer less resistance than the thin copper wire because electrical resistance is inversely proportional to the area of cross-section.

(c) When Rohan increases the temperature of the copper wire by heating it, the number of collisions increases, and hence its electrical resistance also increases.

(d) They offer inherently different resistances because resistance depends strictly on the specific material of the wire, and different materials possess distinct atomic arrangements.

106. Neha built a simple electric circuit to test a small incandescent bulb. She arranged a battery, a switch, and the bulb in a continuous loop. The diagram below depicts the exact state of her components when she stepped back to observe the outcome. Neha noticed that the bulb did not emit any light.



(a) Name the specific state of the electric circuit shown in the diagram and give one reason why the light bulb is not emitting light.

(b) Name the component in the diagram that acts as a source of direct current. State what

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CASE BASED QUESTIONS

101. Rahul was performing an experiment in his physics laboratory to understand the flow of charge. He connected a metallic copper wire to a standard direct current battery and switched on the circuit. Using a precise timer, he allowed the current to flow for exactly forty seconds. He noted the reading on his measuring instrument which displayed a steady current of two point five amperes flowing through the metallic wire. Rahul pondered over the immense number of microscopic particles travelling through the cross-section of the conductor. He recalled his teacher mentioning the elementary charge of a single electron.

(a) Calculate the total amount of charge that passed through the metallic wire in the given time interval.

(b) Calculate the total number of electrons that flowed through the cross-section of the wire if the charge on one electron is.6 $\times 0^{-19}$ C.

(c) Name the physical quantity that constitutes this flow in a metallic conductor and state whether it flows from the positive to negative or negative to positive terminal.

Ans :

(a) $$Q = I \times t = 2.5 \times 40 = 100$$

(b) $$n = Q/e = 100/(1.6 \times 10^{-19})$$
$$= 6.25 \times 10^{20} \text{ electrons}$$

(c) 1. The free electrons present in the metal are the physical quantity responsible for the flow of electric current in a metallic conductor.

2. The electrons always flow from the negative terminal of the source to the positive terminal of the source.

102. Sunita was assisting her teacher in setting up a demonstration board to explain electrical work. She connected two distinct metallic terminals with an insulated conducting wire. Her teacher informed her that a certain amount of work must be done by the power source to transfer charge between these two terminals. Sunita carefully transferred a total charge of five coulombs from the first terminal to the second terminal. The energy meter recorded that exactly sixty joules of work was done during this transfer process. She then used this data to evaluate the electrical characteristics of the setup.

(a) Calculate the potential difference between the two metallic terminals.

(b) State the condition under which the potential difference between two points is said to be one volt. Explain what happens to the force between two charges when they are at an infinite distance.

(c) State the direction of flow of conventional current relative to the direction of flow of electrons.

Ans :

(a) $$V = W/q = 60/5 = 12$$

(b) 1. The potential difference between two points is exactly one volt when the work done in moving one coulomb of charge from one point to another is one joule.

2. The electrostatic force of attraction or repulsion between the two charges becomes strictly zero when they are located at an infinite distance from each other.

(c) Conventionally, the direction of flow of electric current is always taken along the direction of flow of positive charges and entirely opposite to the direction of flow of electrons.

103. Karthik visited an electronics store to purchase power sources for his various household appliances. He first bought a dry cell to power his television remote control, knowing he would have to throw it away once drained. Next, he examined a heavy lead-acid accumulator designed for a car, which the shopkeeper explained could be recharged multiple times. Karthik realized that these two power sources belonged to entirely different categories of electrochemical cells. He decided to tabulate their differences for his science project on direct current sources.

(a) State two differences between the type of cell used in the television remote and the cell used in the car.

(b) Name the energy conversion that takes place in a cell when it is sending current in a circuit, and state whether the chemical reaction in the remote control cell is reversible or irreversible.

Ans :

(a) 1. The primary dry cell used in the remote is non-rechargeable, whereas the secondary lead-acid accumulator used in the car is fully rechargeable.

2. The dry cell is light and provides a weak current, whereas the secondary accumulator is heavy and can draw heavy current.

(b) 1. When a cell sends electric current in a

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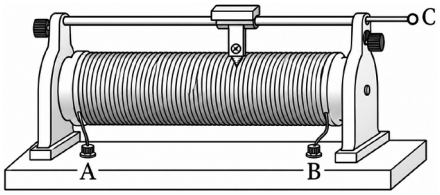
Divya connected her circuit to the specific terminals on this device to utilize it as a variable resistance.



(a) Name the electrical device shown in the diagram and state the specific alloy generally used to make its coiled resistance wire.
(b) State which two terminals Divya must connect to her circuit if she wishes to use this device as a smoothly varying variable resistance.
(c) State which two terminals Divya must connect to her circuit if she wishes to use this device to dispense a fixed resistance.

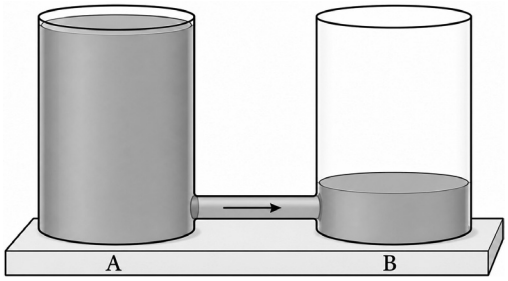
Ans :

(a) 1. The specialized cylindrical electrical device clearly shown in the laboratory diagram is a rheostat.
2. The continuously coiled resistance wire of this specific device is generally manufactured from an alloy called manganin.

(b) To efficiently use the device as a smoothly varying variable resistance, Divya must connect her circuit exactly to the lower fixed terminal A and the upper movable terminal C.

(c) To utilize the device exclusively as a fixed resistance, Divya must connect her electric circuit to the two lower fixed terminals A and B situated at the ends of the wire.

110. Arun was studying the concept of electric potential difference in his classroom. To help him visualise the flow of charges, his teacher presented a physical model involving two interconnected containers filled with a liquid, as illustrated below. Arun observed the direction in which the liquid moved when the pathway between the two containers was opened.



(a) State the physical quantity in the liquid model that corresponds to the electric potential of a conductor. State the physical quantity in the liquid model that corresponds to the flow of electric charges.
(b) Describe the exact condition under which the liquid will stop flowing from vessel A to vessel B. Relate this condition to when the flow of electrons stops between two connected charged conductors.

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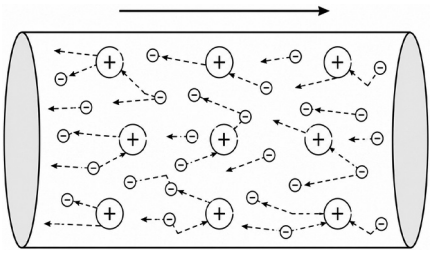
Ans :

(a) 1. The vertical level of water or hydrostatic pressure within the vessels corresponds directly to the electric potential of a metallic conductor.
2. The continuous flow of water through the connecting tube logically corresponds to the flow of electric charges or the electric current.

(b) 1. The liquid will instantly stop flowing when the overall water level becomes exactly the same in both the connected vessels A and B.
2. Similarly, the flow of electrons between two conductors stops completely when both the conductors finally attain an equal concentration of electrons or equal potential.

111. Sanjay was reading about the microscopic behaviour of metallic conductors in his textbook. He studied a magnified cross-sectional view of a wire connected to a battery, which illustrated the internal movement of particles. The diagram below represents the specific motion of these subatomic particles under the influence of an applied voltage. Sanjay carefully noted the interactions happening inside the wire.



(a) Identify the subatomic particles represented by the small circles with a minus sign.
(b) Identify the entities represented by the larger circles with a plus sign.
(c) Name the physical phenomenon offered by the conductor that arises due to the collisions between these moving particles and the fixed

$$V/10 \text{ ohms} = 2.4 \text{ Ampere}$$

Similarly, if we decrease the voltage across the resistor to 6 volts, the current through the resistor will be reduced by half to:

$$I = V/R = 6$$

$$V/10 \text{ ohms} = 0.6 \text{ Ampere}$$

92. Explain the role of geographical location and architectural features in reducing the artificial lighting inside a building.

Ans :

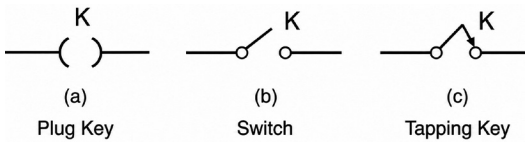
Geographical location and architectural features can play an important role in reducing the need for artificial lighting inside a building. There are some ways in which these factors can affect the amount of natural light that enters a building:

1. Orientation : The orientation of a building can affect the amount of sunlight that enters it. For example, buildings that are oriented towards the south will receive more sunlight than those that are oriented towards the north.
2. Window size and placement : The size and placement of windows can also affect the amount of natural light that enters a building. By placing windows strategically, architects can allow natural light to penetrate deeper into the building, reducing the need for artificial lighting.
3. Location : The geographical location of a building can also affect the amount of natural light that enters it. Buildings located in areas with high levels of sunlight will receive more natural light than those in areas with less sunlight.
4. Building height and shape : The height and shape of a building can also affect the amount of natural light that enters it. Taller buildings can cast shadows on nearby buildings, reducing the amount of sunlight that enters them. By designing buildings with varying heights and shapes, architects can increase the amount of natural light that enters a building.

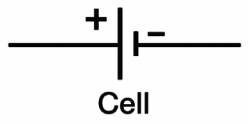
93. Write symbols and state functions of each of following components in an electric circuit :
(i) key,
(ii) cell,
(iii) rheostat,
(iv) ammeter, and
(v) voltmeter.

Ans :

(i) Key: A key is used to put the current on and off in the circuit.

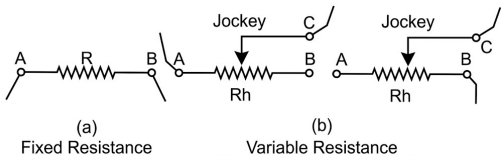


(ii) Cell: It is a device which convert chemical energy into electrical energy. It is represented as:

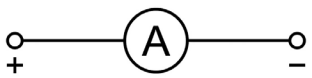


When a large current is needed, we join a number of cells together with cathode of one cell connected to the anode of the other cell. A group of such cells form a battery.

(iii) Rheostat : A rheostat or variable resistance is a device used to change the current in a circuit by changing the length of the resistance wire inserted into the circuit.

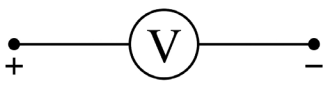


(iv) Ammeter : It is an instrument used to measure the magnitude of current flowing in the circuit.



Symbolic representation of air ammeter

(v) Voltmeter : It is used to measure the potential difference between the two points of circuit.



Symbolic representation of air ammeter

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CHAPTER 10

Magnetism

SUMMARY

1. INTRODUCTION

Lodestone is the first known magnet which was found in Magnesia. It is an ore of iron oxide. The pieces of lodestone found in nature were later categorised as natural magnets. The word 'magnet' is derived from the place of its discovery Magnesia.

2. NATURAL AND ARTIFICIAL MAGNETS

The magnets found in nature are called natural magnets.

When a piece of iron is rubbed with lodestone, it also acquires the magnetic property. The piece of iron so magnetised is known as an artificial magnet.

Some forms of artificial magnets are the bar magnet, horseshoe magnet, magnetic needle and magnetic compass.

A magnetic compass is used to

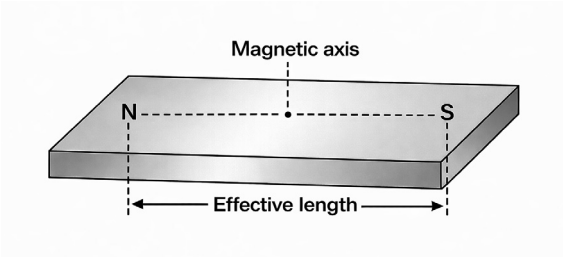
1. Find the north—south direction
2. Find the direction of the magnetic field at a place
3. Plot the magnetic field lines
4. Test the polarity of a magnet

2.1 Properties of a Magnet

A magnet has the following properties:

Attractive Property

1. A magnet has the property of attracting small pieces of iron towards it.
2. Near each end of a magnet, there is a point at which there is maximum attractive property. This point is called the pole of the magnet. A magnet has two poles, one at each end.
3. The poles are not situated exactly at the ends of the magnet, but they are located slightly inside. The distance between the poles of a magnet is called its effective length.



Effective length $= \frac{5}{6}$ Actual length of the magnet

4. The imaginary line joining the poles of a magnet is called the magnetic axis of the magnet.
5. The magnetic axis of a magnet may or may not coincide with its geometric axis.

Directive Property

6. If a magnet is suspended with a silk thread such that it is free to rotate in a horizontal plane, then it always sets itself pointing in the geographic north - south direction.
7. The end of a magnet which points towards the north is called the north - seeking pole or simply the North Pole (N), and the end which points towards the south is called the south-seeking pole or simply the South Pole (S).

Each Magnet has Two Poles

8. When a magnet is broken into two parts, each part is found to be a magnet, that is, each part. is found to have similar attractive and directive properties.
9. When these pieces are broken again and again, each part is still found to retain magnetism.
10. Because the length of each part is reduced, the strength of magnetism in each part is reduced.
11. Monopoles do not exist in a magnet.

Like Poles Repel each other and Unlike Poles Attract each other

12. Two like poles repel each other, while two unlike poles attract each other.

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7. An experiment investigates induced magnetism in a soft iron bar and a steel bar, as summarised in the table.

Step	Procedure	Observation with Soft Iron	Observation with Steel
1	A strong magnet is brought near the bar.	The bar attracts many filings.	The bar attracts few filings.
2	The strong magnet is removed from the bar.	Almost all filings fall off.	Most filings remain attached.

What can be concluded from these observations?
(A) Soft iron is a permanent magnet and steel is a temporary magnet.
(B) Soft iron magnetises easily but loses magnetism easily.
(C) Steel is easier to magnetise than soft iron but has low retentivity.
(D) Both soft iron and steel are difficult to magnetise.

Ans : (B)

The table shows that soft iron attracts many filings (magnetises strongly) in Step 1 but loses them in Step 2, indicating it is easily magnetised and demagnetised. Steel attracts fewer filings (harder to magnetise) but retains them, showing high retentivity. Thus, soft iron magnetises easily but also loses its magnetism easily.

8. When an unmagnetised soft iron bar is placed near a strong permanent magnet, it acquires magnetic properties. What is the nature of this acquired magnetism?
(A) It becomes a permanent magnet with reversed polarity.
(B) It attains purely temporary magnetism that lasts as long as the permanent magnet is near.
(C) It gains permanent magnetism that cannot be destroyed by normal physical means.
(D) It acquires a permanent magnetic field that is perpendicular to the inducing magnet.

Ans : (B)

When an ordinary magnetic material like soft iron is placed near a permanent magnet, it acquires magnetic properties temporarily. This phenomenon is called induced magnetism. The material behaves like a magnet only as long as it remains in the vicinity.

9. **Assertion (A) :** When a piece of iron is brought near a magnet, it is attracted towards the magnet.
Reason (R) : The closer end of the iron piece acquires an opposite polarity by magnetic induction, leading to attraction.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

When an iron piece is placed near a magnet, magnetic induction creates opposite polarity at its closer end. Since unlike poles exert an attractive force, the iron piece moves towards the magnet. This confirms the principle that induction precedes attraction.

10. What is the conventional direction of magnetic field lines outside a bar magnet?
(A) From the south pole to the north pole
(B) From the north pole to the south pole
(C) From the centre of the magnet outwards in all directions
(D) In circular loops parallel to the equator of the magnet

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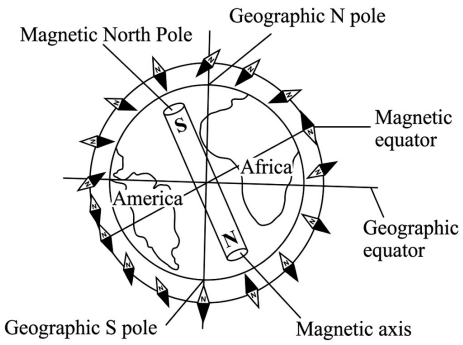
Ans : (B)

Outside a permanent magnet, magnetic field lines are conventionally directed from the north pole towards the south pole. However, inside the magnet, they travel from the south pole to the north pole, forming completely closed and continuous curves.

11. How is a magnetic field defined in physics?
(A) The physical force holding the atoms of a magnet together.
(B) The space around a magnet within which its magnetic influence can be detected.
(C) The region exactly at the center of a bar magnet where the field is zero.
(D) The invisible straight lines connecting the north and south poles directly inside a magnet.

Ans : (B)

A magnetic field is defined as the space around a magnet or a current-carrying conductor within which its magnetic influence can be experienced. It is a vector quantity having both direction and magnitude, determining how magnetic compass needles align.

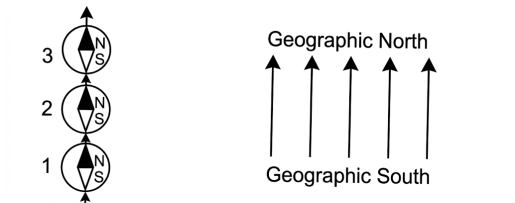


The magnetic needle at different places on earth

The two places where the magnetic needle becomes vertical are called the magnetic poles, and the line joining the two places where the magnetic needle becomes horizontal is called the magnetic equator.

6. PLOTTING OF UNIFORM MAGNETIC FIELD OF THE EARTH

The magnetic field of the Earth is uniform in a limited space.



Magnetic field lines of earth

These lines do not cross each other. They are parallel and equidistant. They are directed from the geographic south to the geographic north.

7. NON-UNIFORM MAGNETIC FIELD OF STRONG BAR MAGNET, AND NEUTRAL POINTS

1. Bar magnet

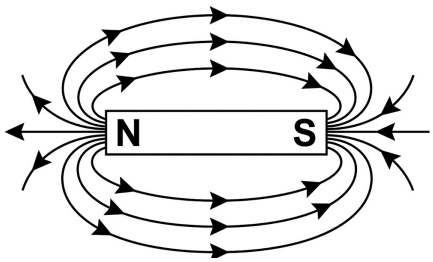


Figure : Magnetic field lines due to a bar magnet

2. Horseshoe magnet

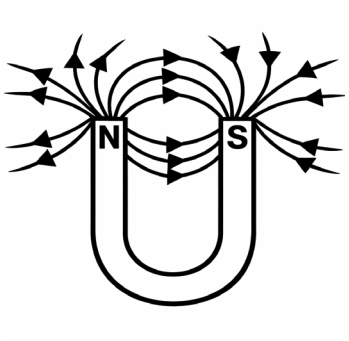


Figure : Magnetic field lines due to a horse shoe magnet

3. Two like poles facing each other

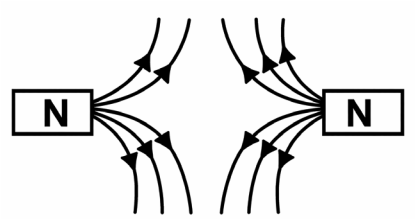


Figure : Magnetic field lines due to two like poles facing each other

4. Two unlike poles facing each other

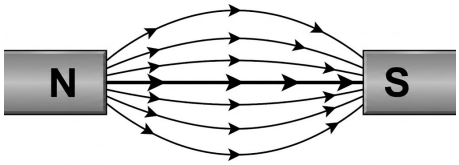


Figure : Magnetic field lines due to two unlike poles facing each other

5. The lines of a non - uniform magnetic field of a bar magnet placed in magnetic meridian, that is, along the direction in which a freely suspended magnet rests can be studied with the following two positions:

7.1 When the given magnet is placed with its North Pole pointing towards north

1. The magnetic field lines obtained in this position are due to the combined effect of the magnetic field of the magnet and the magnetic field of the Earth.

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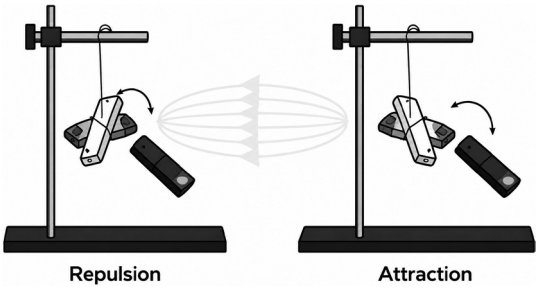
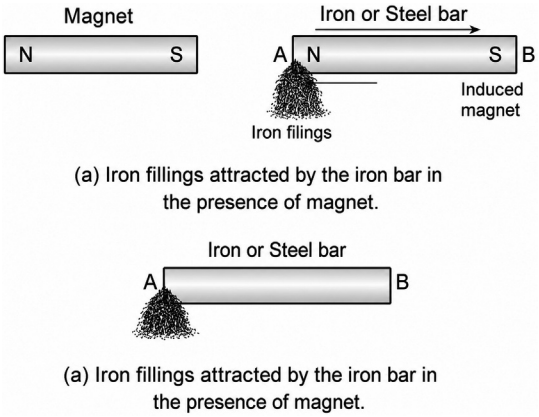


3. INDUCED MAGNETISM

The bar of a magnetic material behaves as a magnet so long as it is kept near or kept in contact with a magnet. This type of magnetism is called induced magnetism. The process in which a piece of magnetic material acquires magnetic properties temporarily in the presence of another magnet is called magnetic induction.

1. A magnetic pole induces an opposite polarity on the near end and a similar property on the farther end.
2. The magnetism acquired by induction is temporary.



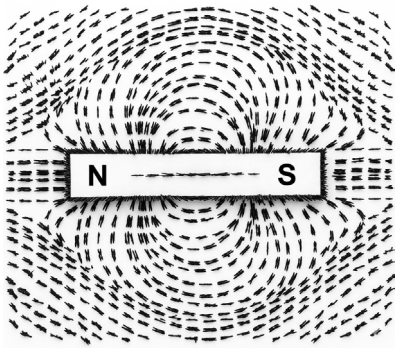
(a) Iron fillings attracted by the iron bar in the presence of magnet.

(a) Iron fillings attracted by the iron bar in the presence of magnet.

4. MAGNETIC FIELD LINES

The space around a magnet in which the needle of a compass rests in a direction other than the geographic north south direction is called the magnetic field.

The effect of the magnetic field of a magnet decreases as the distance from the magnet increases. The direction of the magnetic field at a point is the direction in which the needle of the compass rests when it is placed at that point.



A line of the magnetic field is a continuous curve in the magnetic field such that the tangent at any point of it gives the direction of the magnetic field at that point.

4.1 Properties of Magnetic Field Lines

The properties of Magnetic fields lines area as follows :

1. They are closed and continuous curves.
2. They are directed from the North Pole towards the South Pole of the magnet.
3. The tangent at any point on a field line gives the direction of magnetic field at that point.
4. They never intersect with one another.
5. They are crowded near the poles of the magnet where the magnetic field is strong and are separated near the middle of the magnet and far from the magnet where the magnetic field is weak.
6. Parallel and equidistant field lines represent a uniform magnetic field.
7. They behave like stretched elastic rubber strings, but they have no physical form.

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5. MAGNETIC FIELD OF THE EARTH

The Earth has a magnetic field associated with it and it behaves like a magnet. The existence of the Earth's magnetic field is based on the following facts:

(i) A freely suspended magnetic needle always rests in the geographic north south direction.
(ii) An iron rod buried inside the Earth along the north - south direction becomes a magnet.
(iii) Neutral points are obtained on plotting the field lines of a magnet.
(iv) A magnetic needle rests making different angles with the horizontal when suspended at different places on the Earth.

the first natural magnet discovered in Magnesia. Natural magnets like lodestone possess irregular shapes and relatively weak magnetic strength, making them less suitable for practical usage.

2. Why are artificial magnets generally preferred over natural magnets for practical applications?
(A) Artificial magnets are found abundantly in nature.
(B) Artificial magnets can be made highly powerful and in desired shapes.
(C) Artificial magnets always produce a uniform magnetic field everywhere.
(D) Artificial magnets never lose their magnetic properties under any condition.

Ans : (B)

Natural magnets like lodestone are found in odd, irregular shapes and possess weak magnetic field strength. Consequently, artificial magnets are manufactured from materials like iron or steel to achieve specific convenient shapes and highly powerful magnetic strengths suited for applications.

3. Match the type of magnetic substance in List-I with its corresponding example in List-II.
List-I (Substance Type)
P. Ferromagnetic
Q. Paramagnetic
R. Diamagnetic
List-II (Example)
I. Copper
II. Platinum
III. Cobalt
IV. Lodestone
(A) P - III Q - II R - I
(B) P - IV Q - III R - II
(C) P - III Q - I R - II
(D) P - II Q - III R - I

Ans : (A)

Ferromagnetic substances like cobalt are strongly attracted by magnets. Paramagnetic substances like platinum experience weak magnetic attraction. Diamagnetic materials like copper are not attracted but slightly repelled by strong magnets. Lodestone is specifically classified as a natural permanent magnet.

4. Consider the following statements regarding the properties of magnets:
I. Like poles of two magnets always attract each other.
II. Magnetic poles always exist in pairs and cannot be isolated.
III. The pole pointing towards geographic north is the south pole.
IV. A freely suspended magnet aligns in the geographic north-south direction.
Which of the above statements are correct?
(A) I and III
(B) II and IV
(C) I, II and IV
(D) II, III and IV

Ans : (B)

Magnetic poles always exist in inseparable pairs, making isolated poles impossible. A freely suspended magnet aligns along the geographic north-south direction. However, like poles repel each other, and the pole pointing towards geographic north is defined as the north pole.

5. Permanent magnets are utilized in numerous modern instruments. Which of the following devices does NOT typically use a permanent magnet?
(A) Galvanometer
(B) Heavy-duty industrial crane
(C) Magnetic compass
(D) Voltmeter

Ans : (B)

Permanent magnets are essential components in precision instruments like galvanometers, voltmeters, and compasses to provide stable magnetic fields. However, heavy-duty industrial cranes require powerful temporary lifting capabilities, making the switch-able and highly potent electromagnet the exclusively preferred technological choice for this task.

6. What is the primary function of a magnetic compass?
(A) To measure the exact magnitude of the Earth's magnetic field.
(B) To test the polarity of a given magnet and trace magnetic field lines.
(C) To permanently magnetise ordinary iron bars through induction.
(D) To create strong uniform magnetic fields in laboratory experiments.

Ans : (B)

A magnetic compass consists of a small magnetic needle mounted on a sharp pivot. It can freely rotate in a horizontal plane and is commonly utilized for testing the polarity of a magnet and tracing the lines of magnetic field.

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II. The tangent drawn at any point gives the direction of the magnetic field.
III. Parallel and equidistant field lines represent a non-uniform magnetic field.
IV. They are highly dense near the poles where the magnetic field is strongest.
Which statements are correct?
(A) I, II and III
(B) II, III and IV
(C) I, II and IV
(D) I, III and IV

Ans : (C)

Magnetic field lines are closed continuous curves whose tangent indicates the field direction. They are denser near poles, representing a stronger magnetic field. Parallel and equidistant lines denote a uniform magnetic field, making the statement about non-uniform fields completely incorrect.

18. **Assertion (A) :** Two magnetic field lines can never intersect each other.
Reason (R) : If two lines intersect, a compass needle placed at the intersection would point in two different directions simultaneously.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The tangent to a magnetic field line represents the unique direction of the magnetic field. If two lines intersected, there would be two tangents, meaning the compass needle would have to point in two directions at once, which is physically impossible.

19. **Assertion (A) :** The magnetic north pole of the Earth's internal magnet is located near the geographic south pole.
Reason (R) : A freely suspended compass needle's north pole is attracted towards the geographic north, indicating a magnetic south pole there.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Since unlike poles attract, the north-pointing pole of a compass is attracted to a magnetic south pole. Therefore, the Earth behaves like a massive magnet possessing its magnetic south pole in the geographic north and its magnetic north pole in the geographic south.

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20. A bar magnet is placed in the magnetic meridian with its North pole pointing towards the geographic North. The directions of the magnet's field (B_m) and the Earth's horizontal magnetic field (B_H) are analysed at a point P on the magnet's equatorial line.

Field Component	**Direction at Point P (on the West side)**
B_m (Magnet)	Towards Geographic North
B_h (Earth)	Towards Geographic North

Based on the table, where would a neutral point (where net field is zero) be located in this orientation?
(A) A neutral point is impossible in this orientation.
(B) At point P, since both fields are in the same direction.
(C) At a point where B_m and B_H are equal and opposite.
(D) At the centre of the bar magnet.

Ans : (C)

A neutral point is a location where the net magnetic field is zero. This occurs when the magnetic field from the magnet (B_m) is equal in magnitude and opposite in direction to the Earth's horizontal magnetic field (B_H). At such a point, the two vector fields cancel each other completely.

21. Read the following statements that provide evidence for the Earth's magnetic field:
I. A freely suspended magnetic needle rests in the geographic north-south direction.
II. An iron rod buried along the north-south direction becomes a weak magnet over time.
III. Neutral points are obtained when plotting the magnetic field lines of a bar magnet.
IV. A magnetic needle remains perfectly horizontal at the magnetic poles of the Earth.
Which of the above statements are correct?
(A) I, II and III
(B) II, III and IV
(C) I, III and IV
(D) I, II, III and IV

Ans : (A)

A freely suspended needle resting in the north-

12. **Assertion (A) :** Two magnetic field lines can never intersect each other.
Reason (R) : If two lines intersect, a compass needle placed at the intersection would point in two different directions simultaneously.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The tangent to a magnetic field line represents the unique direction of the magnetic field. If two lines intersected, there would be two tangents, meaning the compass needle would have to point in two directions at once, which is physically impossible.

13. The magnetic axis of the Earth does not coincide perfectly with its geographic axis. What is the approximate angle of inclination between them?
(A) 10 degrees
(B) 20 degrees
(C) 45 degrees
(D) 90 degrees

Ans : (B)

The magnetic poles of the Earth do not align exactly with the geographic poles. The magnetic axis is tilted relative to the geographic axis of rotation. This inclination angle is approximately twenty degrees, causing a natural discrepancy between true and magnetic north.

14. According to the accepted scientific theory, what is responsible for the Earth's magnetic field?
(A) A giant permanent bar magnet buried deep inside the Earth's core.
(B) The high concentration of ferromagnetic materials in the Earth's crust.
(C) Currents formed by molten ferromagnetic materials flowing around the solid inner core due to Earth's rotation.
(D) The gravitational attraction exerted by the Moon and the Sun on Earth's oceans.

Ans : (C)

The Earth's magnetism is not caused by a solid permanent magnet. Instead, it arises from molten ferromagnetic materials located in the outer core. The planet's rotation creates convective fluid currents that act like a massive dynamo, generating the magnetic field.

15. When iron filings are sprinkled over a glass plate covering a bar magnet and tapped gently, they arrange themselves in curved lines. What causes this specific arrangement?
(A) The iron filings possess an inherent natural curved shape.
(B) The Earth's magnetic field pushes the filings into circular patterns.
(C) Each filing gets magnetised by induction and experiences a force aligning it along field lines.
(D) The gravitational pull of the magnet forces the filings into a curved geometric shape.

Ans : (C)

When placed in a magnetic field, individual iron filings acquire temporary magnetism through magnetic induction. They consequently experience magnetic forces that cause them to align along specific continuous curved paths, which visually represent the invisible magnetic field lines accurately.

16. A student observes the pattern of iron filings around a bar magnet to understand its magnetic field. The observations on the spacing of the resulting field lines are tabulated.

Region around Magnet	**Observed Spacing of Field Lines**	**Inferred Magnetic Field Strength**
Near the North and South Poles	Closely spaced (crowded)	X
Near the centre of the magnet	Widely spaced (far apart)	Y

Identify the correct inferences for X and Y.
(A) X = Weak, Y = Strong
(B) X = Strong, Y = Weak
(C) X = Uniform, Y = Non-uniform
(D) X = Zero, Y = Maximum

Ans : (B)

The density of magnetic field lines represents the strength of the magnetic field. Where the lines are closely spaced or crowded, the field is strong. Where they are widely spaced, the field is weak. Therefore, the field strength (X) is strong near the poles and weak (Y) near the centre of the magnet.

17. Evaluate the following statements regarding magnetic field lines:
I. They are closed and continuous curves.

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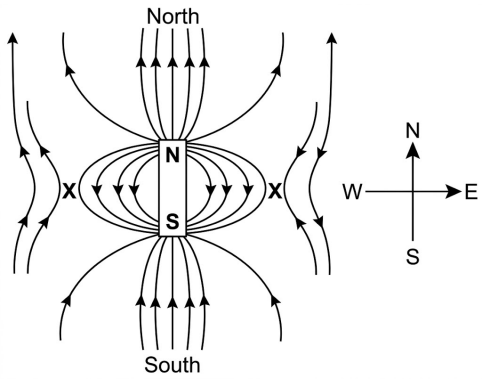
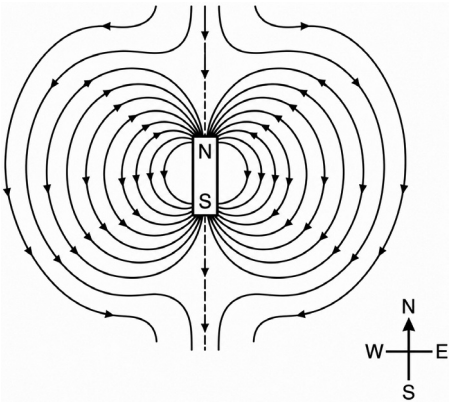


Magnetic field lines of a bar magnet when its north pole N faces geographic north

a. The magnetic field lines in the vicinity of the magnet are curved, and they are mainly due to the magnetic field of the magnet which is stronger than the magnetic field of the Earth.
b. The magnetic field lines at distant points are parallel to each other and are mainly due to the Earth's magnetic field.
c. There are two points equidistant from the centre of the magnet marked as 'X' in the east - west direction, where the magnetic field of the magnet and the horizontal component of the Earth's magnetic field are equal in magnitude, and they are in opposite directions such that the two fields neutralise each other. These points are neutral points.
d. A compass needle when placed at these points remains unaffected, and it rests pointing in any direction.

7.2 When the given magnet is placed with its South Pole pointing towards north

1. The magnetic field lines obtained in this position are due to the combined effect of the magnetic field of the magnet and the magnetic field of the Earth.



Magnetic field lines of a bar magnet when its north pole *N* faces geographic north

a. The magnetic field lines in the vicinity of the magnet are curved, and they are mainly due to the magnetic field of the magnet which is much stronger than the magnetic field of the Earth.
b. The magnetic field lines at distant points are parallel to each other and are mainly due to the Earth's magnetic field.
c. There are two points equidistant from the centre of the magnet marked as 'X' in the north - south direction, where the magnetic field of the magnet and the horizontal component of *p* the Earth's magnetic field are equal in magnitude, and they are in opposite directions such that the two fields neutralise each other. These points are neutral points.
d. A compass needle when placed at these points remains unaffected, and it rests pointing in any direction.

8. NEUTRAL POINTS

Neutral points are the points where the magnetic field of a magnet is equal in magnitude to the Earth's horizontal magnetic field but is in the opposite direction.

If the north pole of the magnet faces towards the geographic north : The neutral points are situated symmetrically on either side of the magnet at equal distances from the centre in the east—west direction.

If the south pole of the magnet faces towards the geographic north : The neutral points are situated symmetrically on either side of the magnet at equal distances from the centre in the north—south direction.

When a compass needle is placed at the neutral points, it remains unaffected because the net magnetic field at these points is zero.

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OBJECTIVE QUESTIONS

1. What is the chemical composition of lodestone, the first known natural magnet?
(A) Iron sulphide
(B) Iron oxide
(C) Copper sulphate
(D) Aluminium oxide

Ans : (B)

Lodestone is a naturally occurring ore of iron oxide, chemically represented as Fe_3O_4. It was

south direction, an iron rod becoming magnetised, and the existence of neutral points all serve as definitive evidence for Earth's magnetism. However, a magnetic needle becomes fully vertical, not horizontal, at the magnetic poles.

22. When a bar magnet is placed on a paper with its south pole pointing towards the geographic north, in which directions are the neutral points found?
(A) East and West directions
(B) North and South directions
(C) North-East and South-West directions
(D) At an angle of 45 degrees to the magnetic axis

Ans : (B)

When a bar magnet is placed with its south pole facing the geographic north, the magnetic field lines of the magnet directly oppose the Earth's magnetic field along the axis. Consequently, the neutral points are located exactly in the north and south directions.

23. When plotting the uniform magnetic field lines of the Earth in a limited space, what characteristic pattern is observed?
(A) The lines form concentric circles around the geographic poles.
(B) The lines are diverging curves moving from south to north.
(C) The lines are parallel and equidistant straight lines directed from geographic south to north.
(D) The lines intersect at multiple locations depending on the local topography.

Ans : (C)

In any small limited space, the Earth's magnetic field is considered perfectly uniform. Therefore, its magnetic field lines are represented as strictly parallel and equidistant straight lines. They are always continuously directed from the geographic south towards the geographic north.

24. Which of the following scenarios produces a non-uniform magnetic field?
(A) The magnetic field of the Earth in a limited empty space.
(B) The magnetic field surrounding a permanent bar magnet.
(C) The magnetic field strictly between the parallel poles of a vast magnet.
(D) The exact center point of a very long current-carrying solenoid.

Ans : (B)

A non-uniform magnetic field is characterized by field lines that are not parallel or equidistant. The magnetic field surrounding any permanent bar magnet or horseshoe magnet is non-uniform, as the field strength varies significantly at different distances from the poles.

25. The strength of an electromagnet is investigated by changing the current and the number of turns in its coil. The strength is measured by the maximum number of identical paper clips it can hold.

Trial	Current (A)	Number of Turns	Paper Clips Held
1	1.0	100	15
2	2.0	100	30
3	1.0	200	31
4	2.0	200	62

Which conclusion is best supported by the data?
(A) Increasing the current has no effect on the electromagnet's strength.
(B) The strength of the electromagnet is directly proportional to both current and number of turns.
(C) Increasing the number of turns decreases the electromagnet's strength.
(D) The strength of the electromagnet depends only on the number of turns.

Comparing Trial 1 and 2 shows that doubling the current (at constant turns) doubles the strength. Comparing Trial 1 and 3 shows that doubling the turns (at constant current) also roughly doubles the strength. Trial 4 confirms this combined effect. Therefore, the data strongly supports the conclusion that the electromagnet's strength is directly proportional to both the current and the number of turns.

26. When a bar magnet is placed with its north pole pointing towards the geographic north, where are the neutral points located?
(A) On the axial line, north and south of the magnet.
(B) On the equatorial line, east and west of the magnet.
(C) Exactly at the center of the bar magnet.
(D) Only at the extreme ends of the north and south poles.

Ans : (B)

When a bar magnet is aligned with its north pole pointing towards the geographic north, the neutral points are formed symmetrically on either side of the magnet. They are situated along the equatorial plane in the exact east and west

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directions.

27. What physical condition defines a neutral point in a magnetic field plot?
(A) The magnetic field of the magnet is maximum while Earth's field is zero.
(B) The magnetic field lines from both poles intersect perpendicularly.
(C) The total resultant magnetic field at that specific point is zero.
(D) The compass needle spins continuously without coming to rest.

Ans : (C)

A neutral point is a specific location where two opposing magnetic fields are exactly equal in magnitude but opposite in direction. This causes them to completely cancel each other out, resulting in a net total magnetic field of exactly zero.

28. The direction of magnetic field lines is crucial for understanding a magnet's behaviour. The table below lists two points relative to a bar magnet.

Location	**Path of a Magnetic Field Line**
Point A (Outside the magnet body)	From the North pole to the South pole
Point B (Inside the magnet body)	Z

What is the correct direction for the path 'Z' inside the magnet?
(A) From the South pole to the North pole
(B) Also from the North pole to the South pole
(C) Radially outwards from the centre
(D) There are no field lines inside the magnet

Ans : (A)

Magnetic field lines form closed, continuous loops. By convention, outside the magnet, they are directed from the North pole to the South pole. To complete the loop, the field lines must travel from the South pole back to the North pole inside the body of the magnet. Therefore, the direction at Z is from South to North.

29. Which of the following is the correct initial sequence of steps when setting up to plot the magnetic field lines of a bar magnet?
I. Place the bar magnet along the drawn line.
II. Fix a sheet of white paper on a drawing board.
III. Mark the outline of the bar magnet.
IV. Mark the true north-south direction on the paper.
(A) I, II, III, IV
(B) II, IV, I, III
(C) IV, II, I, III
(D) II, I, IV, III

Ans : (B)

The correct methodological procedure begins by securely fixing a paper on a board. Next, the geographic north-south direction is accurately marked. The bar magnet is then carefully placed along this directional line, after which its geometric outline is drawn precisely.

30. **Assertion (A) :** A magnetic compass needle placed exactly at a neutral point may rest in any arbitrary direction.
Reason (R) : At the neutral point, the horizontal component of the Earth's magnetic field completely neutralizes the magnetic field of the bar magnet.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Since the horizontal component of Earth's magnetic field exactly cancels out the magnet's field at a neutral point, the net magnetic force is zero. Without any resultant directing force, a sensitive compass needle placed there can rest freely in any direction.

31. Why are the magnetic field lines highly curved and close to each other near the poles of a plotted bar magnet?
(A) The Earth's magnetic field entirely dominates near the poles of the magnet.
(B) The magnetic field of the magnet is much stronger than the Earth's magnetic field in that region.
(C) The glass plate creates a distortion in the magnetic flux.
(D) Magnetic lines naturally tend to form circles regardless of field strength.

Ans : (B)

The magnetic field strength of a bar magnet is intensely concentrated near its poles. In these regions, the magnet's field completely overpowers the relatively weak uniform horizontal component of the Earth's magnetic field, causing the field lines to appear highly curved and densely packed.

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32. Analyze the statements about the occurrence of neutral points:

I. They are formed due to the cancellation of two opposing magnetic fields.

II. A magnet standing vertically with its north pole up has a neutral point on the vertical line away from its north pole.

III. If Earth did not behave like a magnet, neutral points would never be observed for a single isolated bar magnet.

IV. Neutral points always occur exactly at the center of any bar magnet.

Which statements are correct?

(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

Ans : (A)

Neutral points happen when the magnet's field is equal and opposite to Earth's field. Without Earth's magnetism, an isolated magnet wouldn't produce neutral points. A vertical magnet has a neutral point along its vertical axis. However, neutral points never occur precisely at a magnet's centre.

33. What is an electromagnet?

(A) A naturally occurring magnetic stone found deep inside the Earth's crust.
(B) A type of temporary magnet in which the magnetic field is produced by an electric current.
(C) A permanent magnet manufactured exclusively from rare-earth metals and cobalt alloys.
(D) A specially designed device used strictly to measure the Earth's magnetic field.

Ans : (B)

An electromagnet is a highly versatile temporary magnet where the magnetic field is strictly generated by passing an electric current through a conductive coil. The magnetic properties exist only as long as the electric current continues to flow actively through the circuit.

34. Which material is predominantly used to make the core of a highly efficient electromagnet?

(A) Hardened steel
(B) Soft iron
(C) Copper
(D) Aluminium

Ans : (B)

Soft iron is extensively preferred for the core of an electromagnet because it possesses low magnetic retentivity. This essential property ensures that the core rapidly acquires magnetism when the current flows and instantly loses it the moment the current is safely switched off.

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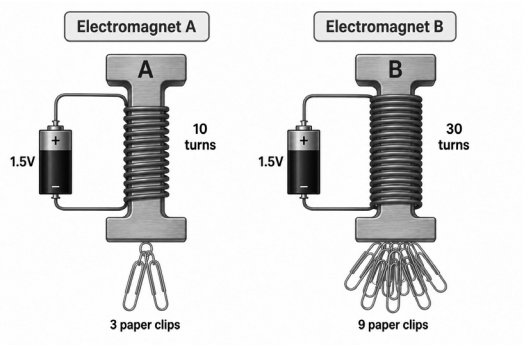
35. The diagram shows two electromagnets, A and B, made with identical soft iron cores and connected to identical batteries. Which electromagnet produces a stronger magnetic field?



(A) Electromagnet A is stronger because there is less wire resistance.
(B) Electromagnet B is stronger because it has a greater number of turns in the coil.
(C) Both are equally strong because they have identical cores and batteries.
(D) Strength cannot be compared without knowing the current.

Ans : (B)

The strength of an electromagnet is directly proportional to two main factors: the magnitude of the current flowing through the coil and the number of turns in the coil. Since both electromagnets are connected to identical batteries (implying similar current), electromagnet B, with more turns of wire, will generate a significantly stronger magnetic field.

36. In an I-shaped electromagnet, what determines the magnetic polarity developed at its ends?

(A) The physical length of the soft iron core.
(B) The chemical composition of the battery used.
(C) The direction of the electric current flowing through the specific end of the winding.
(D) The ambient temperature surrounding the electromagnet.

Ans : (C)

The magnetic polarity at any end of an electromagnet depends entirely on the direction of current flow. If the current flows in a clockwise direction, a south pole is formed. Conversely, an

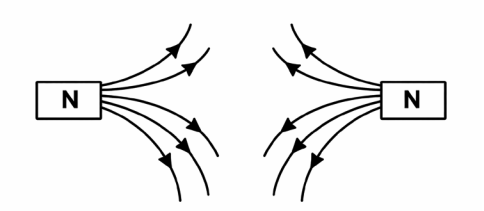
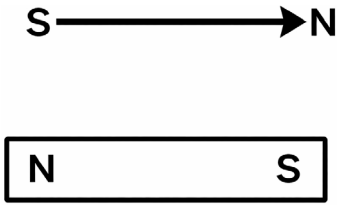


Figure : Magnetic field lines due to two like poles facing each other

90. Figure shows a bar magnet placed on the table top with its north pole pointing towards south. The arrow shows the north - south direction. There are no other magnets or magnetic materials nearby.



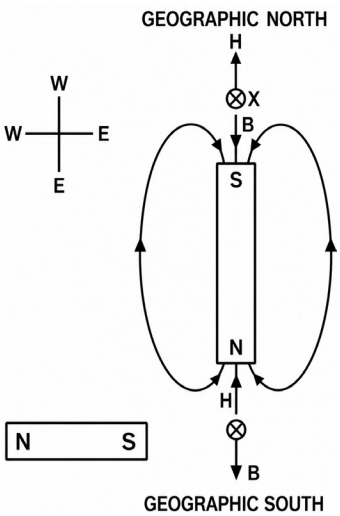
(a) Insert two magnetic field lines on either side of the magnet using arrow head to show the direction of each field line.

(b) Indicate by crosses, the likely positions of the neutral points.

(c) What is the magnitude of the magnetic field at each neutral point? Give a reason for your answer.

Ans :

(X) Neutral points.
(H) Horizontal component of earth's field.



(B) Magnetic field of magnet.

Magnitude of the magnetic field at each neutral point is zero. Since magnetic field of magnet and that of horizontal component of earth's field are equal and act in opposite direction and their resultant at these points is zero.

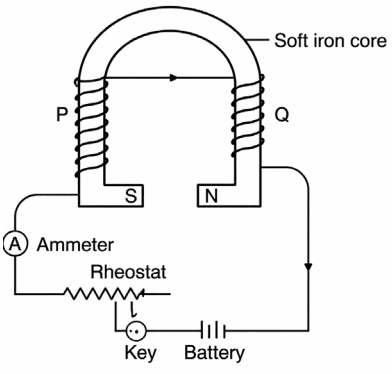
91. Show with the aid of a diagram how a wire is wound on a U - shaped piece of soft iron in order to make it an electromagnet. Complete the circuit diagram and label the poles of the electromagnet.

Ans :

When connected to a current source, the electromagnet becomes energized, creating a magnetic field just like a permanent magnet. The magnetic flux density is proportional to the magnitude of the current flowing in the wire of the electromagnet.

The polarity of the electromagnet is determined by the direction the current. The north pole of the electromagnet is determined by using our right hand. If we wrap our fingers around the coil in the same direction as the current is flowing (conventional current flows from + to −). The direction our thumb is pointing in the direction of the magnetic field, so north pole would come out of the electromagnet in the direction of our thumb.

Below is the circuit diagram of an electromagnet on a horse shoe shaped core with the poles marked and direction of current indicated.



92. Explain the method of plotting the magnetic field lines by using a small compass needle.

Ans :

Magnetic field lines using single bar magnet.
Magnet placed with North pole pointing towards north.

(a) Place the bar magnet on a sheet of paper and draw its boundary with a sharp pencil. The

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(A) Steel possesses a much lower melting point than soft iron.
(B) Steel has significantly higher magnetic retentivity and retains magnetism effectively.
(C) Steel completely repels all magnetic lines of force in nature.
(D) Steel is a perfect diamagnetic material that resists induction.

Ans : (B)

The primary reason steel is utilized for permanent magnets is its remarkably high magnetic retentivity. Once artificially magnetized, it does not easily lose its magnetic orientation. In stark contrast, soft iron loses its induced magnetism almost immediately upon removing the external magnetic field.

43. What is the exact mathematical value of the net resultant magnetic field strictly at any established neutral point?
(A) Maximum
(B) Minimum but non-zero
(C) Zero
(D) Equal to twice the Earth's horizontal component

Ans : (C)

At any correctly identified neutral point, the localized magnetic field generated by the magnet perfectly matches the magnitude of Earth's horizontal magnetic field while acting in the exact opposite direction. This perfect cancellation yields a net resultant magnetic field of absolute zero.

44. What is a major advantage of using an electromagnet over a permanent magnet in industrial applications?
(A) An electromagnet cannot be easily demagnetized by switching off the current.
(B) The magnetic strength of an electromagnet cannot be varied.
(C) The polarity of an electromagnet can be reversed by changing the direction of the current.
(D) An electromagnet is always significantly weaker than any natural lodestone.

Ans : (C)

A major technological advantage of an electromagnet is its tremendous flexibility. Its magnetic polarity can be easily reversed by simply changing the current direction. Furthermore, its overall magnetic field strength can be precisely controlled, unlike the fixed field of a permanent magnet.

45. What effect is primarily observed if a typical standard direct current (DC) battery in an electric bell is completely replaced by an alternating current (AC) source?
(A) The electromagnet will completely fail to magnetise under any circumstances.
(B) The bell will ring continuously without any interruption, independent of the screw contact.
(C) The core will continuously magnetise, but rapid polarity changes will prevent the bell from ringing smoothly.
(D) The bell will ring normally because attraction does not depend on the specific polarity of the electromagnet.

Ans : (D)

If an alternating current source is utilized, the electromagnet's polarity reverses continually. However, the soft iron armature is always physically attracted to a magnetized core regardless of whether it is a north or south pole, allowing the bell to function perfectly normally.

46. Consider the following statements regarding electromagnets and permanent magnets:
I. An electromagnet produces a temporary magnetic field as long as the current flows.
II. The magnetism of a permanent magnet can be varied smoothly by changing current.
III. Permanent magnets are used in delicate measuring instruments like galvanometers.
IV. Electromagnets are heavily used for lifting heavy iron scrap in industries.
Which of the statements are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

Ans : (B)

Electromagnets generate powerful temporary fields widely used for lifting heavy iron scrap. Permanent magnets provide stable magnetic fields essential for instruments like galvanometers. However, the magnetic strength of a permanent magnet is structurally fixed and cannot be varied by an electric current.

47. Match the components of an electric bell in List-I with their corresponding functions in List-II.
List-I (Component)
P. Horseshoe electromagnet
Q. Soft iron armature
R. Hammer
S. Adjusting screw

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List-II (Function)
I. Strikes the gong to produce sound
II. Attracts the armature when current flows
III. Gets attracted towards the poles
IV. Makes contact with the spring strip to complete the circuit
(A) P - II Q - III R - I S - IV
(B) P - I Q - II R - III S - IV
(C) P - IV Q - III R - II S - I
(D) P - II Q - I R - III S - IV

Ans : (A)

In an electric bell, the horseshoe electromagnet generates an attractive magnetic field. The soft iron armature is pulled towards it. The attached hammer mechanically strikes the gong, while the adjusting screw maintains the critical electrical contact with the metallic spring strip.

48. Arrange the following steps in the correct chronological order to describe the working of an electric bell once the switch is pressed:
I. The circuit breaks at the adjusting screw, stopping the current.
II. The electromagnet gets magnetised and attracts the soft iron armature.
III. The electromagnet loses magnetism, and the armature springs back to its original position.
IV. The hammer attached to the armature strikes the gong, producing sound.
(A) II, IV, I, III
(B) I, II, IV, III
(C) II, I, IV, III
(D) IV, II, III, I

Ans : (A)

When closed, the electromagnet attracts the armature. The attached hammer strikes the gong. This physical movement immediately breaks the electrical contact at the screw. The electromagnet consequently demagnetises, allowing the spring strip to pull the armature back, restoring the circuit connection continuously.

ONE MARK QUESTIONS

49. Name one device that uses an electromagnet.

Ans :

Electric Bell.

50. Name the material used for preparing an electromagnet.

Ans :

Soft iron is used for preparing an electromagnet.

51. Why is soft iron used as the core of the electromagnet in an electric bell ?

Ans :

Soft iron is used because it magnetises and demagnetises quickly.

52. Where is the magnetic south pole of the earth located?

Ans :

The magnetic south pole of the Earth is located near the geographic North Pole.

53. What is a lodestone ?

Ans :

Lodestone. A piece of magnetite ore is called natural magnet or lodestone (Leading stone).

54. Can two magnetic field lines intersect each other? Give reason to your answer.

Ans :

No, if they do so, there will be two directions of magnetic field at that point, which is impossible.

55. What kind of magnetic field is represented by parallel and equidistant lines ?

Ans :

Parallel and equidistant lines on a diagram of magnetic fields represent a uniform magnetic field.

56. Explain the meaning of the term induced magnetism.

Ans :

The magnetism acquired by a magnetic material when it is kept near (or in contact with) a magnet is called induced magnetism.

57. What is an electromagnet?

Ans :

An electromagnet is a temporary strong magnet made from a piece of soft iron when current flows in the coil wound around it. It is an artificial magnet.

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58. What is the angle between the magnetic axis of the earth and the axis of rotation of the earth ?

Ans :

The magnetic axis of earth makes an angle of 17 degrees with the axis of rotation (geographic axis) as geographic poles do not coincide with earth's magnetic poles but they are somewhat displaced.

59. Is an electromagnet used as a permanent magnet?

Ans :

No, an electromagnet is not used as a permanent magnet. It produces magnetism only when electric current flows, and loses its magnetism when the current is switched off.

60. A coil of insulated copper wire is wound around a piece of soft iron and current is passed in the coil from a battery. What name is given to the device so obtained? Give one use of the device mentioned by you.

Ans :

The device obtained is called an electromagnet.
One use: It is used in electric bells.

61. How will you test whether a given rod is made of iron or copper?

Ans :

Experiment : Bring a magnet's north pole near one end of given rod, if there is attraction, due to induction then given piece is iron. Now bring the magnet near copper there will be no attraction. Then the given rod is of copper.

TWO MARKS QUESTIONS

62. State two ways through which the strength of an electromagnet can be increased.

Ans :

(i) By increasing the number of turns of winding in the solenoid.
(ii) By increasing the current through the solenoid.

63. State two evidences of the existence of earth's magnetic field.

Ans :

(i) A freely suspended magnetic needle always rests in geographic north - south direction.
(ii) An iron rod burned inside earth along north-south direction becomes a magnet.

64. State two advantages of an electromagnet over a permanent magnet.

Ans :

Advantages of electromagnet over permanent magnet :
(i) Its strength can be changed by changing current.
(ii) It can be readily demagnetised by stopping the current in the solenoid.

65. What conclusion is drawn regarding the magnetic field at a point if a compass needle at that point rests in any direction ? Give reason for your answer.

Ans :

Magnetic field at a point if a compass needle at that point rests in any direction, then this point is known as neutral point and magnetic field due to magnet and that of earth are equal and act in opposite direction and the net magnetic field at this point is zero.

66. 'Induction precedes the attraction'. Explain the statement.

Ans :

When the north or the south pole of a bar magnet is brought near a magnetic material (say an iron bar), the iron bar is attracted towards it (bar magnet). It is because the bar magnet induces an opposite polarity on the near end of the iron bar and similar polarity on its farther end. Consequently the iron bar gets attracted towards the magnet. Hence induction precedes attraction.

67. Fill in the blanks to complete the sentences :
(a) The two ends of a magnet are.....called
(b) Unlike poles of a magnet ..... each other.
(c) Like poles of a magnet ..... each other.
(d) A freely suspended magnet will rest in the geographic .....direction.

Ans :

(a) Poles
(b) Attract
(c) Repel
(d) North - south

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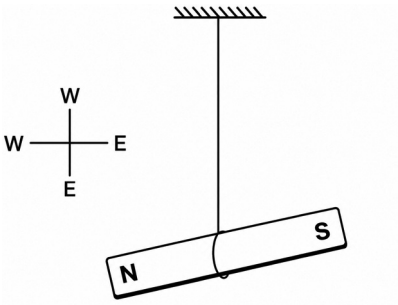
(a) I - shape (or bar) magnet.
(b) U - shape (or horse-shoe) magnet.
The magnetic field of an electromagnet (I or U - shaped) can be increased by the following two ways :
(i) By increasing the number of turns of winding in the solenoid.
(ii) By increasing the current through the solenoid.

82. A small magnet is suspended by a silk thread from a rigid support such that the magnet can freely swing. How will it rest ? Draw a diagram to show it.

Ans :

The magnet will come to rest in the north - south direction with its north pole towards the geographic north pole, making some angle with the horizontal as shown in the figure.

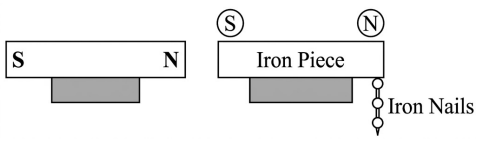


Setting of a freely suspended magnet

83. A small iron bar is kept near the north pole of a magnet. How does the iron bar acquire magnetism? Draw diagram to show the polarity on the iron bar. What will happen if the magnet is removed?

Ans :

A small iron bar is kept near the north pole of a magnet. Then, the part of iron bar near the north pole of magnet, gets the south pole and farther end of iron bar gets north pole. Thus, iron bar becomes a magnet itself.

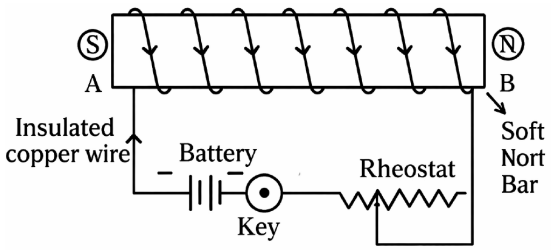


When the magnet is removed from the iron bar then the iron bar loses its magnetism.
This acquiring of magnetism by an iron piece in presence of a magnet and losing it as soon as it is removed from magnet is called magnetic induction.

84. You are required to make an electromagnet from a soft iron bar by using a cell, an insulated coil of copper wire and a switch. (a) Draw a circuit diagram to represent the process. (b) Label the poles of the electromagnet.

Ans :

Process: Wind a number of turns of insulated copper coil around iron bar AB. Connect the cell, Switch and Rheostat in series as shown. On pressing the key bar becomes magnet. End A, S - pole and end B, N - pole.
Key Battery



85. Name the material used for making the armature of an electric bell. Give a reason for your answer.

Ans :

The armature of an electric bell is typically made of soft iron. Soft iron is a good choice of material for the armature because it is easily magnetized and demagnetized, which is necessary for the operation of the electric bell. When an electric current flows through the coil surrounding the soft iron core, it creates a magnetic field that attracts the armature and strikes the gong. The soft iron armature allows for the magnetic field to be strong and quickly formed, while also allowing it to be demagnetized just as quickly when the current stops flowing. This allows for the armature to quickly return to its original position, resulting in the repeated striking of the gong and the ringing of the bell. Additionally, soft iron is relatively easy to machine and shape, which makes it a practical choice for manufacturing the armature of an electric bell.

86. 'Induced magnetism is temporary'. Comment on this statement.

Ans :

If one pole of the bar magnet is brought near the iron nails as shown in figure below :-

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Two neutral points will be at equal distance from the centre of magnet and lying on equatorial line of magnet towards East and West direction.

(ii) When the North pole pointing towards south. Two neutral points will be at equal distance from the centre of magnet and lying on Axial line of magnet towards North and South direction.

76. What is an artificial magnet ? State two reasons why do we need the artificial magnets ?

Ans :

An artificial magnet is a magnetised piece of iron or steel. Some forms of artificial magnets are : bar magnet, horseshoe magnet, magnetic needle, magnetic compass etc.

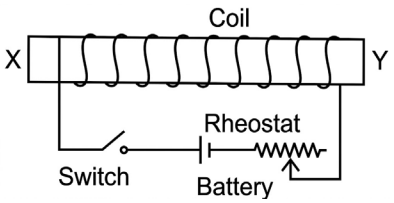
Reasons for using Artificial Magnets as natural magnets are weak irregular shaped cannot be used as such. For different uses, artificial magnets are made of iron in different magnetic sizes and shapes.

A bar magnet, horse shoe magnet, magnetic needle, magnetic compass etc. are few artificial magnets.

77. In figure, shows a coil wound around a soft iron bar XY.

(a) State the polarity at the ends X and Y as the switch is pressed.

(b) Suggest one way of increasing the strength of electromagnet so formed coil



Ans :

(a) X - north pole ; Y - south pole.

(b) By reducing resistance of the circuit by means of rheostat to increase current.

THREE MARKS QUESTIONS

78. Explain what do you understand by magnetic induction. What role does it play in attraction of a piece of iron by a magnet?

Ans :

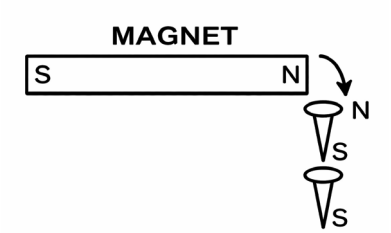
Magnetic Induction. When a magnet is brought near a piece of iron it becomes a magnet and remains magnet so long as the magnet is near it, the nearer end becomes opposite polarity while farther end same polarity. The magnetism so acquired is called induced magnetism.

The nearer end with opposite poles attract each other and the piece (iron) is attracted towards magnet.

79. Explain the mechanism of attraction of iron nails by a magnet when brought near them.

Ans :

This mechanism is called magnetic induction. The nearer end of nail is oppositely magnetised and opposite poles attract each other, the nail gets attracted towards magnet.



80. You are provided with two similar bars, one is a magnet and the other is a soft iron bar. How will you distinguish between them without the use of any other magnet or bar ?

Ans :

Take first bar and suspend it in a stand with the help of a thread. So that it is free to rotate in horizontal plane. Note the direction in which it sets itself. If the direction is North and South it may be magnet. Again rotate it, if this time again it sets itself in north and south direction, it is a magnet, otherwise it is iron.

Now repeat above experiment with second bar and in the same way find it if it sets always in north and south direction then it will be a magnet.

81. How is an electromagnet made? Name two factors on which the strength of magnetic field of the electromagnet depends.

Ans :

An electromagnet can be made in any shape but usually the following two shapes of electromagnet are in use :

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anticlockwise current flow directly establishes a magnetic north pole.

37. Which of the following actions will efficiently increase the strength of an electromagnet?
(A) Decreasing the total number of turns of wire in the coil.
(B) Decreasing the magnitude of the electric current passing through the coil.
(C) Increasing the magnitude of the current and the number of turns in the coil.
(D) Replacing the soft iron core with a highly insulated plastic rod.

Ans : (C)

The overall magnetic strength of an electromagnet can be effectively enhanced by increasing the magnitude of the electric current flowing through the circuit. Additionally, increasing the total number of conductive wire turns wound tightly around the core will proportionally boost the field strength.

38. How is the insulated copper wire wound on the two arms of a U-shaped (horseshoe) electromagnet to ensure strong opposite polarities?
(A) The wire is wound in the same clockwise direction on both arms simultaneously.
(B) The wire is wound strictly in opposite directions on the two arms when seen from the ends.
(C) Only one arm is completely wound with wire while the other is left totally bare.
(D) The wire is continuously wound back and forth randomly over both poles.

Ans : (B)

To construct a functional horseshoe electromagnet, the insulated copper wire must be carefully wound in opposite directions over the two parallel arms. This specific technique guarantees that one end securely develops a north pole while the other distinctly becomes a south pole.

39. **Assertion (A) :** For supplying current in the coil of an electromagnet with a fixed polarity, a direct current (DC) source must be used.

Reason (R) : If an alternating current (AC) source is used, the polarity at the ends of the electromagnet will constantly change.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

A direct current (DC) source provides a steady unidirectional flow, ensuring constant magnetic polarity. If an alternating current (AC) source of 50 Hz is applied, the direction of current continuously reverses, causing the magnetic polarity to completely alternate fifty times every second.

40. A bar magnet is placed with its South pole pointing towards the geographic North. The combined magnetic field is plotted. The table describes the conditions along two distinct axes relative to the magnet's centre.

Axis	**Relationship between B_m and B_h**
Axial Line	B_m and B_h are in opposite directions at points near the poles.
Equatorial Line	B_m and B_h are generally in the same direction.

Based on this information, where will the neutral points be located?
(A) On the equatorial line.
(B) On the axial line.
(C) At the corners of the magnet.
(D) Inside the body of the magnet.

Ans : (B)

Neutral points form where the magnet's field and Earth's field are equal and opposite. The table indicates that this condition of opposition occurs along the axial line (the line passing through the poles). Therefore, the neutral points must be located somewhere on the axial line, at positions where the magnitudes of the two fields are also equal.

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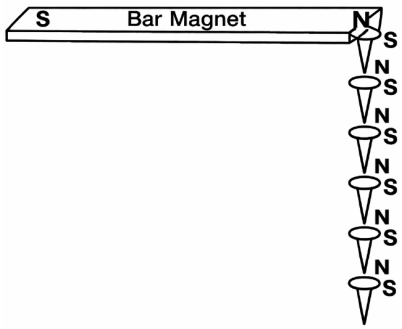
41. Which material is generally utilized for making strong permanent magnets due to its high magnetic retentivity?
(A) Soft iron
(B) Pure zinc
(C) Steel
(D) Copper

Ans : (C)

Steel is exceptionally well-suited for manufacturing permanent magnets because it exhibits significantly high magnetic retentivity compared to soft iron. Once steel is fully magnetized by a strong field, it effectively retains its magnetic properties for an extended period without degrading.

42. Why is steel considered fundamentally superior to soft iron for manufacturing permanent magnets?



Magnetic induction

The reason is that the bar magnet induces magnetism in an iron nail which gets attracted by the magnet and clings to it. This nail magnetises the other nail by magnetic induction and attracts it. This continues till the force of magnetic attraction on the nail, is sufficient to balance the weight of nails. Holding the uppermost nail in position, if the magnet is removed, the nails lose their magnetism and get separated from each other and fall down. Thus the magnetism acquired by induction is purely temporary.

FOUR MARKS QUESTIONS

87. How is the working of an electric bell affected, if alternating current be used instead of direct current?

Ans :

The working of an electric bell is affected if alternating current (AC) is used instead of direct current (DC) in the following ways:

1. Ringing frequency: An electric bell relies on the magnetic field created by the current flowing through the coil to attract the armature and strike the gong. With (DC), the current flows in one direction and produces a steady magnetic field, which causes the armature to strike the gong at a certain frequency. However, with (AC), the direction of the current changes back and forth, causing the magnetic field to also change direction. As a result, the armature moves back and forth rapidly, causing the bell to ring at the frequency of the (AC).
2. Increased wear and tear: The rapid back - and - forth movement of the armature caused by (AC) can result in increased wear and tear on the moving parts of the electric bell.
3. Higher voltage requirements: Because (AC) voltage alternates between positive and negative values, the peak voltage of an (AC) signal is higher than the average voltage of a (DC) signal of the same amplitude. As a result, an electric bell designed to operate on (DC) may require a higher voltage to operate on (AC).

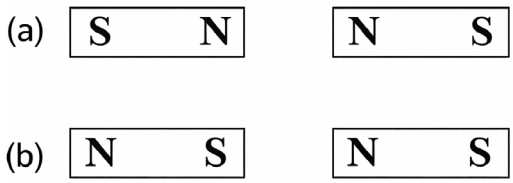
88. State two differences between an electromagnet and a permanent magnet.

Ans :

The difference between an electromagnet and a permanent magnet are as follows :

	Electromagnet	**Permanent magnet**
1.	It is made of soft iron.	It is made of steel.
2.	It produces magnetic field so long as current flows in its coil. i.e., it produces temporary magnetic field.	It produces a permanent magnetic field.
3.	The magnetic field strength can be changed.	The magnetic field strength cannot be changed.
4.	Magnetic field of an electromagnet can be very strong.	Magnetic field of a permanent magnet is not so strong.

89. In figure, draw at least two magnetic field lines between the two magnets.



Ans :

(a)

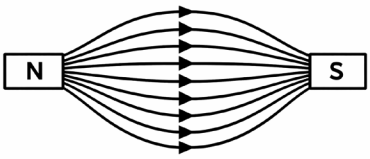


Figure : Magnetic field lines due to two unlike poles facing each other

(b)

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68. Complete the following sentences.
(a) If the field lines in a magnetic field are parallel and equidistant, the magnetic field is .....
(b) At a neutral point, the resultant magnetic field is ..... .
(c) The neutral points of a bar magnet kept with its north pole pointing towards geographic north are located ..... .

Ans :

(a) Uniform,
(b) Zero,
(c) On either side of the magnet in east and west.

69. What is a natural magnet ? State two limitation of a natural magnet?

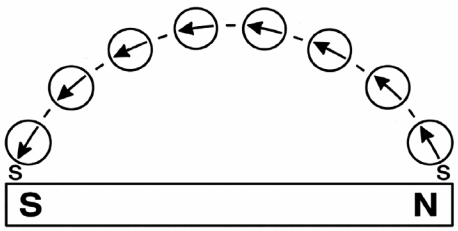
Ans :

Natural magnet. Pieces of lodestone magnetite i.e. oxide ore of iron (Fe_3O_4)] found in nature are called Natural magnet.
Natural magnets are found in irregular and odd shapes. Moreover, they do not have strong power for use. So artificial magnets of iron or steel are made in different shapes and sizes as are required.

70. What do you understand by the term magnetic field lines ?

Ans :

It may be defined as the path curved or straight along which a unit north pole moves when free to do so.



71. State four properties of the magnetic field lines.

Ans :

Properties of magnetic field lines are as follows :
(1) No two magnetic lines of force can intersect each other.
(2) The tangent to magnetic lines of force at any point gives the direction of magnetic field at that point.
(3) They start from north pole and end at south pole (outside the magnet).
(4) Magnetic lines of force contract longitudinally and they dilate laterally.

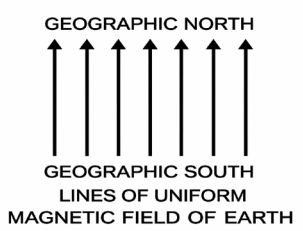
72. Explain why iron filings which are sprinkled on a sheet of cardboard placed over a bar magnet, take up a definite pattern when cardboard is slightly tapped.

Ans :

We know that a magnet has magnetic field around it. Iron filings which are sprinkled on a sheet of cardboard over a bar magnet take up a definite pattern when the cardboard is slightly taped, because iron filings set themselves along magnetic lines of force as iron filings are magnetised by induction and arrange themselves in curved lines called magnetic lines of force.

73. Sketch four magnetic field lines as obtained in a limited space on a horizontal plane in the earth's magnetic field alone.

Ans :



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74. What is a neutral point ? How is the position of neutral point located with the use of a compass needle ?

Ans :

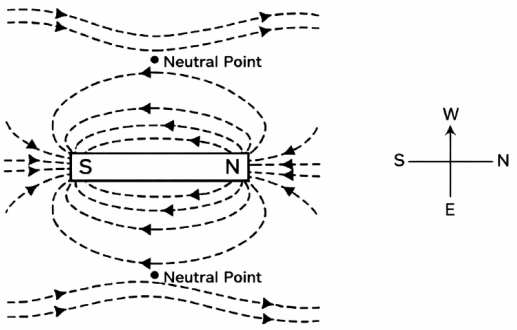
A neutral point is a point where the magnetic field due to a current-carrying conductor or a magnet is equal and opposite to the Earth's magnetic field, so the resultant magnetic field is zero.
Location of Neutral Point using a Compass Needle :
The neutral point is located by moving a compass needle around the conductor. At the neutral point, the compass needle shows no deflection and remains aligned in the north–south direction.

75. State the positions of neutral points when a magnet is placed with its axis in the magnetic meridian and with its north pole
(i) pointing towards geographic north
(ii) pointing towards the geographic south.

Ans :

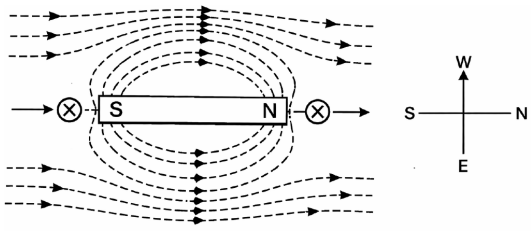
(i) When north pole pointing towards north.

paper is fixed on a drawing board. Now set the drawing board such that north pole of magnet is towards the north. Draw boundary of drawing board with a chalk.
Now place a small compass needle close to the north pole of magnet and mark two pencil dots exactly at the two ends of the needle. Then remove the compass and place it again in such a way that one end of the needle coincides with the second pencil dot. Mark the position of the other end of the needle with a dot. Repeat the process of moving the compass needle till the other end of bar magnet is reached. Join the different dots to get a continuous smooth curve. Thus, one magnetic field line is traced.
Repeat the process from the same pole but from different point and trace out another magnetic field line. In this way, draw several magnetic field lines put arrow on each line from north to south.



Pattern of magnetic field lines obtained is shown in figure.

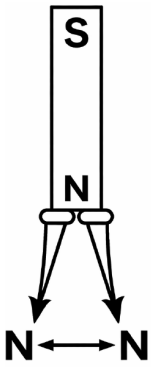
(b) In the same way another pattern of magnetic field lines can be obtained when magnet is placed with its south pole pointing towards north.



93. Explain the following :
(a) When two pins are hung by their heads from the same pole of a magnet, their pointed ends move apart.
(b) Several soft iron pins can cling one below the other from the pole of a magnet.
(c) The north end of a freely suspended magnetic needle gets attracted towards a piece of soft iron placed a little distance away from the needle.

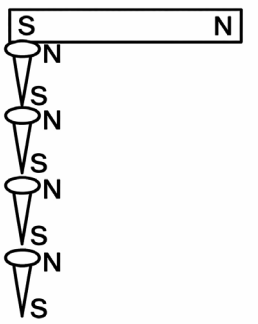
Ans :

(a) Two pins hung by their heads from the same pole of a magnet, their pointed ends fly apart, because of repulsion between the like poles as shown in figure.



The magnetic induction produces same polarity i.e. (North - North) on the pointed ends due to which they repel each other.

(b) If a pin is brought near a pole of a bar magnet, magnetic induction takes place and iron pin gets attracted by the magnet and clings to it. This pin magnetises the other pin by magnetic induction and attracts it. This continues till the force of magnetic attraction is sufficient to balance the weight of pins.



Holding the uppermost pin in position, if the magnet is removed, the pins lose their magnetism and get separated from each other and fall down.

(c) It is due to attraction between magnet and iron piece.

94. (a) Draw the pattern of magnetic field lines near a bar magnet placed with its north pole pointing towards the geographic north.

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(a) Pure iron belongs to the class of ferromagnetic substances, which are materials strongly attracted by a magnet and easily magnetized.
(b) Pure aluminium belongs to the class of paramagnetic substances, which are materials that are only weakly attracted by a strong magnet.
(c) Pure copper belongs to the class of diamagnetic substances, which are materials that are not attracted but rather repelled by the poles of a strong magnet.
(d) The space around the magnet within which it exerts its influence on these cubes is called the magnetic field of the magnet.

96. Meera wanted to verify the presence of the Earth's magnetic field. She took a completely unmagnetised soft iron rod measuring 50 cm in length and buried it horizontally about two metres deep inside the earth. She specifically aligned the rod along the geographic North-South direction. After leaving the rod undisturbed in the ground for a few days, she dug it out and brought a small tracing compass near its ends. She observed that the compass needle showed deflection, confirming that the rod had acquired magnetic properties.
(a) Name the type of magnetism acquired by the buried soft iron rod.
(b) Give one reason why the soft iron rod acquired magnetic properties when buried in the earth along the North-South direction.
(c) State two other evidences, apart from the buried iron rod, that support the existence of the Earth's magnetic field.

Ans :

(a) The soft iron rod acquires induced magnetism, causing it to behave like a weak magnet after being buried inside the earth for a few days.
(b) The earth itself behaves like a huge magnet, and its magnetic field induces temporary magnetic properties in the soft iron rod placed along the North-South direction.
(c) 1. A freely suspended magnetic needle always comes to rest in the geographic north-south direction due to the earth's magnetic influence.
2. Neutral points are obtained when plotting the magnetic field lines of a bar magnet, which occurs due to the neutralization by the earth's horizontal magnetic field.

97. Rohit was experimenting with magnetic materials in his laboratory. He held a strong permanent magnet and brought a soft iron nail near its north pole. He observed that the iron nail got attracted and held onto the magnet. He then attached three more identical soft iron nails, one below the other, forming a chain. When he carefully removed the permanent magnet from the top nail, all the soft iron nails immediately fell apart. He then repeated the exact same experiment using steel paper clips instead of soft iron nails and noticed a distinct difference when the magnet was removed.
(a) Name the phenomenon that causes the first iron nail to be attracted to the permanent magnet.
(b) State the polarity developed at the lower end of the first soft iron nail when its upper end is attached to the north pole of the magnet.
(c) Compare what happens to the chain of soft iron nails versus the chain of steel paper clips when the permanent magnet is removed, giving one reason for this difference.

Ans :

(a) The phenomenon is called induced magnetism, which occurs when a magnetic material acquires magnetic properties temporarily due to the presence of a nearby permanent magnet.
(b) The polarity developed at the lower end of the first soft iron nail will be a north pole, similar to the magnet's farther end polarity.
(c) 1. The chain of soft iron nails falls apart completely because soft iron loses its induced magnetism immediately when the permanent magnet is removed.
2. The chain of steel paper clips does not fall apart because steel retains some of its induced magnetism even after the permanent magnet is removed.

98. Kiran assembled an electric bell circuit using a 6 V direct current (d.c.) battery, a U-shaped electromagnet with a soft iron core, a soft iron armature, and a metallic spring strip. When she pressed the switch, the hammer struck the gong repeatedly and the bell rang perfectly. Curious about alternating current, she replaced the 6 V d.c. battery with an alternating current (a.c.) source of frequency 50 Hz. Her classmates predicted that the bell would stop ringing because the polarity of the electromagnet would constantly change.
(a) State whether the electric bell will ring or not when connected to the 50 Hz alternating current source.
(b) Explain the working principle of the armature and the electromagnet in this circuit, and give one reason why the changing polarity of the alternating current does not prevent the armature from being attracted. (3)

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Ans :

(a) The electric bell will continue to ring perfectly when connected to the 50 Hz alternating current source just as it did with direct current.

(b) 1. When current flows, the soft iron core gets magnetized and attracts the soft iron armature, causing the attached hammer to strike the gong.
2. This movement breaks the circuit at the contact screw, demagnetizing the electromagnet, and the spring pulls the armature back, restoring contact to repeat the process.
3. The alternating current changes polarity 50 times in one second, but the attraction of the soft iron armature does not depend on the polarity of the electromagnet.

99. Arjun constructed an I-shaped electromagnet by tightly winding a thin insulated copper wire around a soft iron bar. He created 100 turns of winding and connected the ends to a 12 V battery. He observed that the electromagnet could lift a maximum of 20 small iron pins. He wanted to modify his electromagnet so that it could lift at least 40 iron pins. He decided to change the physical parameters of the coil and the circuit without replacing the soft iron core itself.

(a) State two specific ways by which Arjun can increase the strength of the magnetic field produced by his electromagnet.

(b) State two advantages of an electromagnet over a permanent magnet of the same size.

Ans :

(a) 1. Arjun can increase the total number of turns of the insulated copper wire winding around the soft iron solenoid.
2. Arjun can increase the magnitude of the electric current flowing through the solenoid by using a stronger battery source.

(b) 1. The strength of the magnetic field of an electromagnet can be easily changed by varying the current, which is not possible in a permanent magnet.
2. The polarity of the electromagnet can be reversed by changing the direction of current, whereas the poles of a permanent magnet cannot be altered.

100. Rahul found an unmarked rectangular metallic bar on the laboratory table. To determine if it was a magnet, he suspended it horizontally from a rigid support using a fine silk thread, ensuring it could spin freely. After a few oscillations, the bar settled in the geographic north-south direction. He marked the end pointing towards the geographic north with a red dot. Later, he accidentally dropped the bar, and it broke into two unequal pieces. He picked up the piece with the red dot and tested its ends.

(a) Name the magnetic pole that exists at the end marked with the red dot.

(b) State what Rahul will observe at the broken end of the piece containing the red dot.

(c) Name the general property of a magnet that allows it to align in the north-south direction when suspended freely.

(d) State the position of the Earth's magnetic north pole relative to the geographic poles.

Ans :

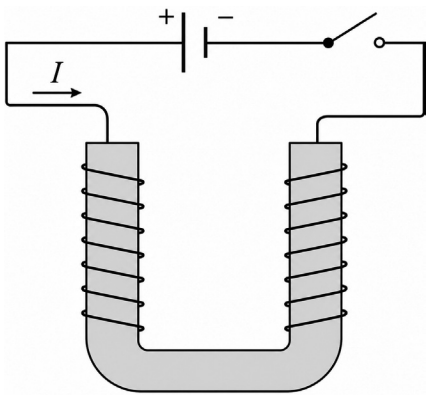
(a) The end of the freely suspended metallic bar that points towards the geographic north is known as the north pole.

(b) Rahul will observe a new south pole at the broken end of the piece containing the red dot, because isolated magnetic poles cannot exist independently.

(c) The general property that allows a magnet to align itself roughly in the geographic north-south direction is known as the directive property of magnets.

(d) The Earth's magnetic north pole is located near the geographic south, positioned approximately at 71.72 degrees south latitude and 148.32 degrees east longitude.

101. Anil was studying the magnetic effects of electric current. He constructed a U-shaped electromagnet using a soft iron core and connected it to a battery through a key. He observed the polarity developed at the two free ends of the core when the current was switched on.



(a) Identify the direction of current flow (clockwise or anticlockwise) at the bottom

face of the left arm when viewed from below.

(b) State the magnetic polarity developed at the bottom end of the left arm and the bottom end of the right arm.

(c) State what happens to the magnetic field in the gap between the two poles when the key is opened, and give one reason why soft iron is used for the core.

Ans :

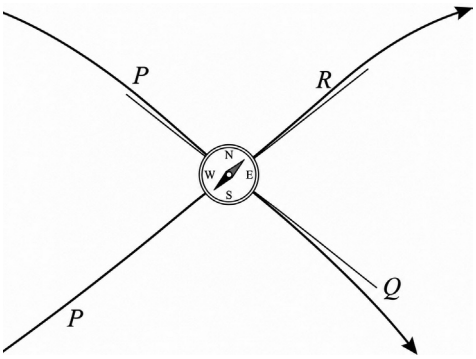
(a) When viewed from below, the direction of the current flowing at the bottom face of the left arm is in the clockwise direction.

(b) The bottom end of the left arm develops a south pole, while the bottom end of the right arm develops a north pole.

(c) 1. When the key is opened, the current stops flowing and the magnetic field in the gap disappears immediately as it acts as a temporary magnet.

2. Soft iron is used for the core because it easily loses its magnetic properties as soon as the electric current is switched off.

102. Rohan was learning to sketch the space around magnetic materials. He drew a diagram showing two curved paths crossing each other and placed a small compass needle at the exact point where they met to determine the direction.



(a) State the theoretical property of magnetic field lines that Rohan's diagram violates.

(b) Give one reason why it is practically impossible for the compass needle to rest at the intersection point as shown in the diagram.

Ans :

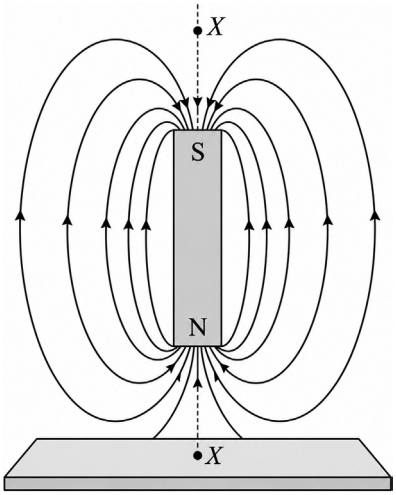
(a) 1. The diagram violates the fundamental property that two magnetic field lines can never intersect or cross one another at any point.

2. Magnetic field lines represent the unique direction of the magnetic field, meaning a single point can only have one specific direction of magnetic influence.

(b) 1. If the compass needle is placed at the intersection point, it would have to point in two different directions simultaneously, along both tangents.

2. Since a single compass needle cannot physically point in two different directions at the exact same time, intersection of field lines is impossible.

103. Neha placed a bar magnet on a drawing board and used a magnetic compass to plot its field lines. She aligned the magnet along the magnetic meridian with a specific orientation and identified two points where the compass needle remained unaffected.



(a) State the geographic direction towards which the upper end S of the bar magnet is pointing in this setup.

(b) Name the specific term used for the two points marked X on the diagram.

(c) Explain why the resultant magnetic field at the points marked X is zero.

Ans :

(a) The upper end S of the bar magnet is pointing towards the geographic north, meaning its south pole faces the geographic north.

(b) The specific term used for the two points marked X on the central vertical axis of the diagram is neutral points.

(c) 1. At the neutral points, the magnetic field caused by the bar magnet is equal in magnitude to the horizontal component of the earth's magnetic field.

2. The resultant magnetic field becomes zero because these two equal magnetic

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Indicate the position of neutral points by marking $\times$.

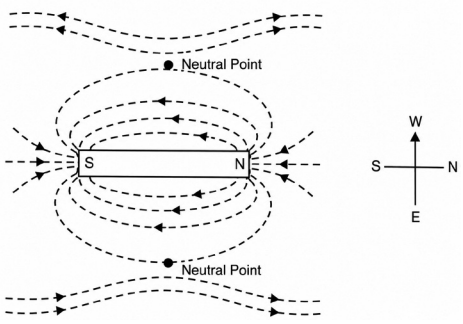
(b) State whether the magnetic field lines in part (a) represent a uniform magnetic field or non-uniform magnetic field ?

Ans :

(a) Magnetic field lines using single bar magnet. Magnet placed with North pole pointing towards north.

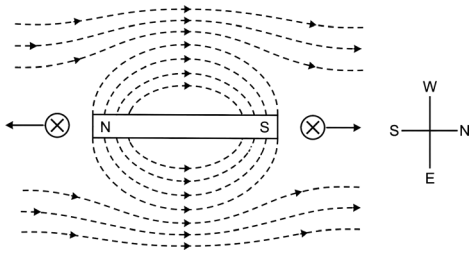
(i) Place the bar magnet on a sheet of paper and draw its boundary with a sharp pencil. The paper is fixed on a drawing board. Now set the drawing board such that north pole of magnet is towards the north. Draw boundary of drawing board with a chalk.

Now place a small compass needle close to the north pole of magnet and mark two pencil dots exactly at the two ends of the needle. Then remove the compass and place it again in such a way that one end of the needle coincides with the second pencil dot. Mark the position of the other end of the needle with a dot. Repeat the process of moving the compass needle till the other end of bar magnet is reached. Join the different dots to get a continuous smooth curve. Thus, one magnetic field line is traced.

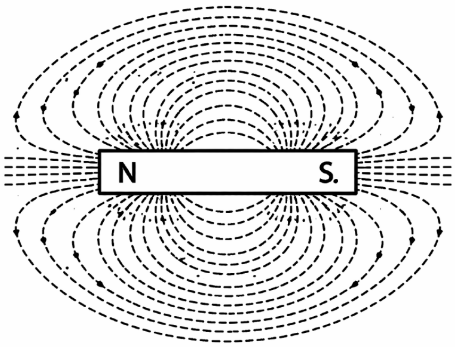


Repeat the process from the same pole but from different point and trace out another magnetic field line. In this way, draw several magnetic field lines put arrow on each line from north to south. Pattern of magnetic field lines obtained is shown in figure.

(ii) In the same way another pattern of magnetic field lines can be obtained when magnet is placed with its south pole pointing towards north.



(b) The magnetic field lines of a bar magnet alone represent a non - uniform magnetic field because these lines are not equispaced and parallel but they are either converging or diverging or curved as shown in the figure below :



CASE BASED QUESTIONS

95. Kavita was sorting various materials found in her school's physics laboratory to classify them based on their magnetic properties. She had a strong permanent bar magnet and three small solid cubes made of pure iron, pure aluminium, and pure copper, respectively. She carefully brought the strong bar magnet near each cube one by one. She noticed that the iron cube moved quickly towards the magnet, the aluminium cube experienced a very slight pull, and the copper cube showed absolutely no attraction at all.

(a) Name the class of magnetic substances to which iron belongs.

(b) Name the class of magnetic substances to which aluminium belongs.

(c) Name the class of magnetic substances to which copper belongs.

(d) State the term used for the space around the strong bar magnet within which it exerts its influence on these cubes.

Ans :

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(a) Identify the specific type of permanent magnet shown in the diagram.
(b) State why the curved lines in the gap appear to push one another away laterally.
(c) Explain why the magnetic field is particularly strong between the two poles N and S.
(d) State the general property of magnetic field lines regarding their geometric nature outside a magnet.

Ans :

(a) The specific type of permanent magnet shown in the diagram is a horseshoe magnet, which is essentially a bar magnet bent into a U shape.
(b) The curved lines between the ends appear to push one another away laterally due to the property that different magnetic field lines tend to repel each other.
(c) The magnetic field is particularly strong between the two poles because the unlike poles of a horseshoe magnet are positioned very close to each other.
(d) Outside the magnet, the magnetic field lines always form continuous closed curves that are directed from the north pole towards the south pole.

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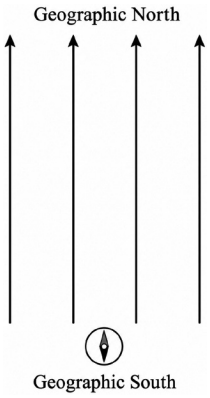
fields act in exactly opposite directions, completely neutralizing each other at these specific points.

104. Simran placed a plain sheet of paper on a wooden table in a room with no artificial magnets nearby. She used a small compass needle to trace a series of straight paths from one edge of the paper to the other, plotting the natural magnetic environment of the Earth.



(a) State the nature of the magnetic field represented by these parallel and equidistant straight lines.

(b) State the direction in which a freely suspended magnetic needle will rest in this specific magnetic field, and name the term used for the imaginary vertical plane containing this alignment.

Ans :

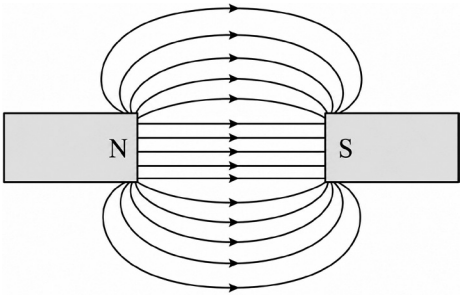
(a) 1. The parallel and equidistant straight lines represent a perfectly uniform magnetic field within a limited space, maintaining constant strength and direction.

2. In this specific limited space, the horizontal component of the earth's magnetic field exerts a completely uniform magnetic influence across the plotted area.

(b) 1. A freely suspended magnetic needle in this uniform field will rest exactly parallel to the lines, pointing towards the geographic north direction.

2. The vertical plane containing this natural alignment of the geographic north and south poles of the Earth is called the geographical meridian.

105. Manish placed two identical rectangular magnets on a table, separated by a small gap. He sprinkled iron filings over them and tapped the table to reveal the pattern of the combined magnetic field in the space between the two magnets.



(a) Name the type of force existing between the two facing ends of the rectangular bars.

(b) State the direction of the magnetic field lines inside the left rectangular bar.

(c) State the rule that determines the direction of the arrowheads on the curved lines outside the bars.

(d) Identify what the concentration of curved lines in the central gap indicates about the magnetic field there.

Ans :

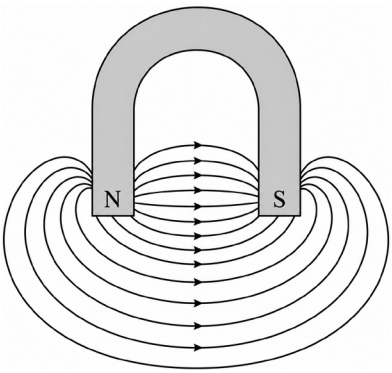
(a) The type of force existing between the facing North pole and South pole of the two rectangular bars is a strong force of attraction.

(b) Inside the left rectangular bar, the direction of the magnetic field lines is from the south pole towards the north pole of that specific magnet.

(c) The arrowhead direction is determined by the rule that magnetic field lines outside a magnet are always directed from the north pole to the south pole.

(d) The dense concentration of curved lines in the central gap indicates that the magnetic field is very strong in the region between the two unlike poles.

106. Divya placed a U-shaped permanent magnet flat on a drawing board. She mapped the space around its ends using iron filings and traced the paths showing how the magnetic influence travels between the two adjacent ends.



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